# Metallurgical and Chemical Engineering

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## The Westward Trend.

It is no disparagement to the East, where the foundation of this country has been laid, to acknowledge the fact that the centre of productive activity is steadily moving westward. While the nerve centre of this country will remain in New York, which appears destined to grow in restlessness and nervosity, the productive capacity grows by westward expansion of the development, going on with gigantic strides, of the bountiful natural resources of this country. To every action there is a reaction, and to prove that this westward trend reacts on, and changes, the East, the instance of Mr. Roosevelt's career is sufficient. The policy of the conservation of the natural resources—perhaps the most momentous of all problems in the modern political and industrial life of this country—is born of the necessity to regulate this westward expansion in the best interest of all the people. In this westward expansion the engineer takes an important part. He is the pathfinder. The builders of the roads, the bridges, the railways, are the advance guard of the army that is out to conquer nature. It is essentially the civil engineer, the mechanical engineer, the mining engineer who bear the brunt of this pioneer work. The metallurgist and the chemist follow later, for the same reason why metallurgical and chemical engineering are younger professions than civil, mining, and mechanical engineering. As long as placer mining pays, there is no need for chemical and metallurgical research. But the time comes when the chemist and metallurgist are needed. It often comes "too soon." When the rich ores are exhausted, the simple methods fail and the metallurgist has to devise new ways and means. This is the raison d'être of the rapidly growing importance of the specialized metallurgical engineer in the West and of the slow but sure dissociation of the metallurgical from the mining engineer.

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Chemical engineering, aside from metallurgy, needs a more highly developed civilization to manifest intensively its usefulness. But the time seems to have arrived when the chemist should begin to interest himself more energetically in the West from a professional standpoint. The American Chemical Society recognized this by holding its Summer meeting in San Francisco; and this meeting was so successful that it will be remembered as a milestone in the career of the oldest of our chemical societies which has regained so much youthful vigor and energy in recent years. That the West is bound to gain much from chemistry in years to come, goes without saying. That the pilgrims from the East who participated in this trip to the West brought back for themselves Western enthusiasm is evidenced by the story of the trip told by one of the participants in our correspondence columns in this issue—by the way, a little literary masterpiece. The American Electrochemical Society, though not going so far, follows in the same direction by holding its Autumn meeting in October in Chicago. So far

quite an attractive industrial sight-seeing program has been arranged and it may be hoped that the meeting will attract many Eastern members. "East is East and West is West." But the extremes should meet each other in their own quarters. It is an indication of sound judgment of the managing councils of our chemical societies that they pay due regard to the westward trend of industrial evolution and its importance for the future of chemistry in this country.

## Copper-Nickel Steels.

The fact brought out in Mr. David H. Browne's paper before the American Institute of Mining Engineers, that in the besse-merizing of copper-nickel matte, copper and nickel together act like a single metal and that in the monel alloy directly produced from the ore the nickel and copper are contained in practically the same proportion as in the ore, is surprising in many respects. As explained by Mr. Browne in detail, the facts disprove some former theoretical notions on the subject. It is perhaps even more surprising that copper and nickel when added together to steel should behave also to a certain extent like one metal, so that it is possible to replace a certain amount of nickel in nickel-steel by copper, without changing the properties mate-rially. In our last issue we published a very interesting paper by Prof. C. F. Burgess and Mr. J. Aston on copper-nickel-iron alloys, made from pure electrolytic iron, free from carbon. Not less interesting is a paper recently presented by Mr. G. H. Clamer before the American Society of Testing Materials and published in abstract in our present issue. It supplements the Burgess-Aston paper in the practically important point that the steels of Mr. Clamer contained carbon. The problem is, of course, an exceedingly complicated one and further detailed and systematic researches are necessary. But the results so far obtained look decidedly promising, and it really seems that copper has about finished its rôle as a bugbear in steel metal-lurgy. If monel steel is practically as satisfactory as nickel steel, the considerable price difference between the monel alloy and nickel should have a decisive effect and should open for nickel steels—or rather for monel steels—many new applications in engineering. That even the best informed are still in the dark with respect to some of the most fundamental questions is proven by Mr. Browne's frank statement that by melting copper and nickel together they could not produce an alloy identical in its properties with monel alloy obtained directly from the ore, in spite of apparently the same composition.

## Superficial Criticism.

In a recent address before the Technical and Engineering Society of the Colorado School of Mines, Mr. George E. Col-lins discussed the fallacy of passing criticism on technical methods in use in any district, without a full knowledge of all the conditions. The milling methods of Gilpin County, Colo-rado, have been subject to drastic condemnation, but when they are examined in the light of the conditions under which they are applied, they are found to be a logical development of those conditions, and, in the main, perhaps, satisfactory. The milling problem of a district like Gilpin County is not a simple one. The diversity of ore and the large number of mines producing small tonnage make the problem complex, with the result that the ultimate practice must be somewhat of a compromise.

Thus it is that the superficial observer, visiting mills of this kind, is apt to level his criticism at the methods without full knowledge of the reason for their existence. As a matter of fact, none of the mills may be best suited to the ore from the technical point of view, but may, nevertheless, give the best commercial saving over a long period of operation.

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A favorite form of criticism of milling methods is based on superficial observation of the mineral particles passing into the waste. The customary comment is to the effect that "modern" devices would effect a better saving. Quite probably they would. Perhaps, also, the machines already in use could make a better saving, but at a cost not taken into consideration by the critic. The commercial side of ore reduction is the ulti-mate criterion of success. Where freight and treatment charges have to be considered, it is frequently a nice problem to solve, whether to ship the bulky crude ore and incur the freight and treatment expense, or subject it to a dressing process with its attendant losses. Generally speaking, the methods existing in an old district cannot be compared with modern methods, and should not, therefore, come under condemnation on that score alone. The methods used in such a district usually represent the combined judgment of many men in one or two genera-tions, and represent a very considerable capital investment. Wholesale scrapping is often not only a sign of progressive-ness, but shrewd business policy which soon pays. Many ex-amples from the history of the iron and steel industry prove this. But as long as the owner of a large works in which con-siderable capital is invested is satisfied to let things well enough alone, progress cannot be hoped for from new methods, but rather from new men working under the given conditions and improving them slowly.

## Kick's Law.

An engineering rule, like a scientific law, should be a state-ment of fact based on a large number of observations which give concordant results. A law thus formulated cannot be said to be infallible, but it is true for our state of knowledge at the time and stands accepted as long as no new facts are dis-covered which controvert it. There is always the possibility that the law may not stand the test of newly discovered facts, and frequently a generally accepted law may not be questioned until something arises to direct special attention to it. Fur-thermore, having developed an acceptable scientific law, there still remains the necessity of making proper application of it to the solution of any problem. The recent admirable efforts to determine the crushing efficiency of various machines has directed renewed attention to Kick's law, which is stated thus. The energy required for producing analogous changes of con-figuration of geometrically similar bodies of equal technologi-cal state varies as the volumes or weights of those bodies.

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The proposal to apply the elements of this law to determine relative efficiencies of crushing appliances, from a grading analysis of the crushed product, has not been accepted without question. While no doubt is cast on the mathematical truth of the law as stated, it is doubted whether the law applies to the question in hand. The assumption of the "equal technologi-cal state" of the various constituents of an ore is erroneous.

and the application of the law in some instances certainly gives results that cannot be accepted. For example, the comparative efficiency of the stamp and tube mill on Rand banket ore, when determined by the application of Kick's law to the grading analysis, is greatly in favor of the stamp, which does not accord with practical experience. This is due to the conglomerate nature of the Rand ore. Comparatively little energy is required to separate the pebbles from each other and to crush the cement to a fine mesh. All of this makes a good showing for the stamps, especially when crushing coarse. On the other hand, the tube mill has to deal with uniformly hard, coarse ore from which the softer and finer particles have been separated. It is, therefore, unfair to apply Kick's law to this problem.

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On further consideration it will be found that many other ores are of such a nature that Kick's law is inapplicable, on account of the unequal technological state of the constituent minerals. Massive mixed sulphides present one crushing problem, which, however, changes as soon as the constituent minerals have been freed from each other. Similarly granite might come under the law until that point in its reduction is reached where we no longer have granite, but rather its constituents. Probably very few natural ores will be found of equal technological state, and the energy required to crush them cannot, therefore, be determined by the proposed method. It is for this reason, mainly, that metallurgists have not accepted wholly the work of recent investigators, although they recognize progress in the work thus far done.

## Iron Ore and Pig Iron Production.

Recent forecasts made in some quarters that this season's movement of Lake Superior ore will fall below that of last year appear to be based upon the assumption that pig iron production in the twelvemonth beginning July 1 last will fall materially short of that in the preceding twelvemonth. That is an assumption which is hardly warranted. In round figures the production in the twelvemonth ended June 30 last was 30,000,000 tons. It is true that the rate of production has since dropped nearly 5,000,000 tons below, but the rate was higher at the end of the twelvemonth than at the beginning, and the maximum rate during the twelvemonth was reached in February, or later than the middle of the period. It is normal for the productive rate to fall off very materially in midsummer. Considering all circumstances it is as likely that production will be above as under 30,000,000 tons in the twelvemonths beginning with last July. Before entering into the arithmetic of the case, a brief résumé of the Lake Superior ore movement may be given. The total movement of Lake Superior ore has been as follows, the figures covering the movement down the lakes and the movement by all-rail routes:

|      | Gross tons. |
|------|-------------|
| 1904 | 21,849,401  |
| 1905 | 34,384,116  |
| 1906 | 38,565,762  |
| 1907 | 42,266,668  |
| 1908 | 26,014,987  |
| 1909 | 42,586,869  |

The early predictions, made in the winter, when the iron industry was running at a considerably faster gait than the present, were that this season's movement would be about 50,000,000

tons, and more likely over than under that quantity. Lately there has been a reversal of opinion, some predictions recently made being that no more than 35,000,000 tons to 38,000,000 tons will be moved. En passant, it may be noted that if the movement is to be confined to so small a total, a drastic reduction in shipments must be made, for to Aug. 1 21,863,549 tons came down the lakes, and the August movement has been forecasted at 6,500,000 tons, and this represents a gain over 1909 of 5,800,000 tons, so that a mere continuance, after Sept. 1, of the 1909 rate would make a total for the season of about 48,400,000 tons.

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The estimates of annual consumption of iron ore in the United States made by the Geological Survey show a total of 359,000,000 tons in the 10 years ended with 1908. The figures do not take account of furnace stocks, nor of some other details, and on account of the growth of the industry and industrial conditions at the beginning and end of the decennial period it is probably not unfair to assume that there was such an increase in furnace stocks as to reduce the actual consumption in the 10 years to about 350,000,000 tons. The pig iron production in the same period, as officially reported, was 185,632,841 gross tons, which gives a ratio of practically 1.9 tons of ore to 1 ton of pig iron. The ratio, as we shall have occasion to consider later, tends to increase, as the ores mined are steadily, although slowly, growing leaner year by year. In a year of full activity the production of ore outside the Lake Superior region amounts to about 10,000,000 tons. The Lake ores brought down in 1909 were substantially for the blast-furnace year July 1 to June 30. Then we have, roughly, for the year ended June 30 last the following supplies:

| | |
|---|---|
| Lake ore shipments, 1909 | 42,586,869 |
| Imports less exports to June 30 | 1,837,362 |
| Production outside Lake Superior | 10,000,000 |
| Total | 54,424,231 |

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Allowing for a slight increase in the outside production we may take 55,000,000 tons. For the 30,000,000 tons of pig iron produced we should have required, at the ratio of 1.9, 57,000,000 tons, showing a deficiency of 2,000,000 tons. For a production of 30,000,000 tons of pig iron in the succeeding twelvemonth we should make up the deficiency and provide against another deficiency, by moving 4,000,000 tons more of Lake ore than in last season. Furthermore, as the iron content of ore is decreasing, the factor of 1.9 derived by the experience of the 10 years 1899 to 1908 is too low, and to cover that we should also move more ore. Finally, it seems to be taken for granted, in the retrospect, that the large imports of the past twelvemonth should have been discouraged as far as possible. Altogether, then, it would appear that to support 30,000,000 tons of pig iron production in the twelvemonth begun July 1 the Lake ore movement should be well in excess of the 42,500,000 tons moved last year, and a movement of between 48,000,000 tons and 50,000,000 tons would not be excessive. From the other viewpoint, a movement of only 35,000,000 tons of Lake ore this season would represent provision for the production of only 25,000,000 tons or 26,000,000 tons of pig iron in the twelvemonth begun July 1. It is utterly improbable that the requirements will be so light as this.

## The Western Metallurgical Field.

### International Smelting & Refining Company.

The lighting of the first fires in the furnaces of this company's new copper smelter in Utah occurred on July 25, 1910. The incident recalls the announcement of General Manager E. P. Mathewson in the first annual report of the company, to the effect that the plant would probably be ready for operation about Aug. 1, 1910. Following is a brief description of the plant as presented in the company's annual report by Mr. Mathewson, under date of June 1, 1910.

The company's railway, known as the Tooele Valley Railway, six and one-half miles in length, connects the smelter site known as International, with Tooele Junction on the San Pedro, Los Angeles and Salt Lake Railway. The plant consists of a sampling mill, capacity 4500 tons daily, fitted with two complete sets of Brunton sampling machinery and thoroughly equipped in every particular, driven by electric motors. In connection with the sampling mill are sampling ore bins of about 6000 tons capacity, from which the ore is taken to the sampling mill by belt conveyers. After sampling the ore is taken again by belt conveyers either to blast-furnace storage bins of about 3000 tons capacity, or to toaster storage bins of about 5000 tons capacity. From the blast-furnace storage bins the ore is to be removed by the local tramming system in electrically operated cars. From the roaster bins the ore will be removed by belt conveyers passing over a conveyer weighing scale, thence to roasters.

Each roaster building contains 16 roasters of the McDougall type, 32 in all, each with a capacity of 40 tons of dry ore in 24 hours, the smoke from the roasters passing directly into a large dust chamber fitted with hoppers and arranged for the introduction of the system of wire filters such as is in use at the Great Falls plant of the Anaconda Copper Mining Company, at the expense of merely hanging the wires. This dust chamber is connected by a large flue to a stack which is 350 ft. in height and 25 ft. inside diameter at the top. The calcined material from the roasters, together with flue dust from the dust chamber, is trammed to the top of the reverberatory building and discharged into hoppers directly over the reverberatory furnaces, and thence by gravity to the furnaces themselves.

The sample mill is fireproof throughout, having a steel frame and reinforced concrete floors and steel housings for the elevators. The bins are all of steel construction, but the approaches to the receiving bins are of timber frame. The roaster building is all steel with the exception of the roof, which is of wood covered with sheet iron. The office and shop buildings are of steel construction with concrete floors, but with wooden partitions with expanded metal lath on the office end, so that practically the entire plant is fireproof with the exception of the office partitions and part of the roof of the roaster building and sampling mill.

The reverberatory plant consists of five furnaces of the Anaconda type, measuring 19 ft. x 102 ft. on the hearth, capacity 275 tons of calcined material each per day. The reverberatories have four waste heat boilers attached to them, and in addition thereto three hand-fired boilers for spares. These boilers will furnish steam to the power plant which is a brick and steel structure fitted up with two triple expansion vertical engines, each directly attached to 700-kw, alternating-current generators. There are also two horizontal compound engines, two blowing engines for converter blast and two 90-lb. compressors for general utility. In addition there are the usual accompaniments of condensers, feed-water heaters, pumps for feed water and fire protection, and space has been left for the installation of blast-furnace blowers should a blast furnace be decided on later. The building is fireproof throughout, and fitted with an overhead crane electrically operated.

The converter building adjoins the reverberatory building and is a fireproof structure of steel with a clay floor. The converter stands are five in number, manufactured by the Power & Mining

Machinery Company, and are electrically operated. There is a compressed air-tamping plant at one end of the converter building, and a 60-ton crane is installed in the main aisle for the moving of heavy material, slags, etc. The matte from the reverberatories will be tapped directly into the converters, and slag from the converters will be taken in large ladles by cross cranes to the reverberatory furnaces and poured in hot. This will make a minimum amount of cold slag to be handled. Copper from the converters will be transferred in ladles to the copper cake molds in the casting shed adjoining, and at first poured from the ladles into the molds and then loaded on cars for shipment. When business increases it will be necessary to put in a casting machine, space for which has been left.

The plant will receive ore from the Utah Consolidated mines over a cableway which is now in operation with a capacity of 100 tons per hour. Recently a contract also has been made to treat ore from the South Utah Company's mines. Mr. Mathewson closes his report with the statement that there is no better constructed or designed smelting plant for copper ores in existence.

### Improvements at Cananea.

The cost of copper production at the reduction works of the Cananea Consolidated during 1909, including every expenditure, was 11.64 cents per pound, according to the report of General Manager L. D. Ricketts. This cost has been abnormally high, but improvements have been made which are expected to reduce this figure. Conservation of the water supply has been effected by impounding tailing, and using the clarified water in the mill. Loss in concentration is being reduced by the introduction of Cole drag classifiers which, it is estimated, will raise the recovery to 80 per cent. Considering the grade of material concentrated, this will be very good work. It is expected that all of the improvements and changes in the mill will enable the company to treat 25 per cent more ore than formerly.

The operations of the reduction division have been exceedingly satisfactory, both regarding metallurgical results and costs. There has been a reduction in the cost of beneficiating ores and concentrates, and this reduction will continue. The cost per dry ton of new copper bearing material treated for the past several periods has been as follows:

| Year. | Total cost. |
|-------|-------------|
| 1907  | $6.82       |
| 1908  | 3.86        |
| 1909  | 3.09        |

This reduction is largely due to increased efficiency of the reverberatory furnace and to decreased cost of power, and to the fact that barren material has been replaced by marginal material in the converting department. Concentrator slime has gradually replaced barren clay, and carefully selected ore has been mixed with barren quartz in the linings, until near the end of 1909 nothing but ore and slime were used. Finally, it was discovered that American ore was sufficient as a lining without any clay, and at present this ore is being used exclusively as converter lining without mixture of clay, either in the bodies or the lids of the converters, and while the combined silica and alumina amounts to but little over 70 per cent, as compared with 89 per cent in the barren quartz, greater efficiency is obtained, pound for pound, with the former than with the latter lining. This is largely due to the fact that the ore forms a more compact lining and withstands mechanical erosion. Necessarily the slag has become more basic, and now contains 62 per cent ferrous oxide. As a consequence, the converter slag has become a very valuable flux and has very largely replaced the barren iron and lime formerly used.

Experiments are being conducted to determine stack losses, which have been found to be serious. The best method to be used to save the minute percentage of dust in the enormous tonnage of stack gases is hard to determine, but preventive measures are to be introduced first. In line with this idea, a second reverberatory furnace with accessory battery of boilers,

and six additional calcining furnaces, will be installed. This will remove much of the fine material from blast-furnace treatment and largely decrease the quantity of dust made. At the same time, the fine material will be smelted more cheaply and the blast furnace capacity will be increased; directly by taking the fine material from them, and indirectly by increasing the capacity per square foot of hearth area. By this arrangement the smelting capacity will be nearly double the tonnage handled in 1909.

The use of fuel oil for power has proved of great advantage. Fuel bills per ton of ore have been cut almost in two despite the fact that more power per ton of ore is used than formerly. It is expected that this year will see the complete abandonment of all steam plants except those at the power house and concentrators. Power costs have dropped during the past two years from over $16 to under $8 per hp-month, and it is expected that as low as $6 power ultimately will be obtained.

When the smelter and concentrator enlargements now under way are completed, the plant will have a monthly capacity of 6,000,000 lb. of copper, if run on the present grade of ore.

### Ore Dressing in the Cobalt District.

About a year ago the Temiskaming Mining Company, of Cobalt, Canada, authorized the erection of a concentrating mill. Following is a brief description of the system installed, as given by General Manager Norman R. Fisher. The low-grade ore is crushed in a No. 5 gyratory crusher and 36-in. x 14-in. rolls to pass a ¾-mesh screen, and transferred to storage bins. The first recovery is made in jigs of the Richards pulsator type, three of these machines being installed to handle material down to 14 mesh. All material finer than this is treated on James tables and slimers. It is found that the fine material is very rich owing to the occurrence of a large quantity of friable silver minerals, such as proustite, tetrahedrite and argentite, which, with fine leaf silver, is released from the gangue in crushing. It is estimated that the jig and table section of the mill will effect the recovery of about 80 per cent of the total extraction, or about 68 per cent of the total silver content of the ore.

Up to this stage the capacity of the mill is about 250 tons per 24 hours, but this section will be operated only during the day shift until such time as it is found expedient to increase the capacity of the stamp section.

The tailing from the jigs is dewatered and delivered into the stamp bins of 350 tons capacity. Six 1250 lb. stamps designed for rapid crushing will handle the jig tailing, which is then classified, the coarse material passing to James tables and the fine to Callow thickening tanks preparatory to treatment on slime tables. The capacity of the stamp section will be 80 to 90 tons per 24 hours.

Provision is also made for the installation of regrinding machinery to treat the table tailing if found advisable, and all tailings are to be conserved with a view to future treatment by lixiviation should it be found the mechanical loss renders this an economic necessity. It is expected that the mill will effect a saving of 85 per cent of the silver content of the ore, at an estimated average cost of treatment, including maintenance and power, of about $1.75 per ton.

### The Non-Ferrous Metal Market.

The matter of greatest interest in the metal market for the past few weeks has been the proposed curtailment of copper output for the purpose of reducing the stock on hand and allowing the market prices to regain some degree of firmness. It may be said that the Phelps Dodge and the Calumet & Hecla interests have reduced output, and that Amalgamated and the porphyry coppers will undoubtedly do the same. The July output of the refineries has already indicated the curtailment, and it is expected that the next three months will witness a return to a more stable equilibrium between supply and demand.

With one or two exceptions in the minor metals, the market has been characterized by general dullness.

**Copper.**—The reported curtailment has had a noticeable effect on the consumers, some of whom have bought heavily for future delivery as well as for immediate use. Prices have remained fairly steady at 12⅝ cents for lake and 12½ cents for electrolytic. There is a tendency to higher prices.

**Lead.**—The market has been quiet and without feature. Few transactions have been noted, the dullness having extended throughout the month. The St. Louis quotation is 4.27½ to 4.30 cents; New York, 4.40 cents.

**Zinc.**—Both demand and supply have been noticeably small, but prices have been generally firm. Consumers are not using more than their immediate demands require and no change is looked for until consumption increases. St. Louis quotations are 5 to 5.02½ cents; New York, 5.15 to 5.17 cents.

**Tin.**—Metal for immediate delivery has commanded a premium over future, which is a rather unusual condition. The New York market has been firm at 33¼ cents.

**Other Metals.**—The market for aluminium has been quiet with demand falling off somewhat. No. 1 ingots command 22.5 cents per pound. Prices on antimony have been nominal with practically no demand for the metal. Various brands are quoted at 7.5 to 8.2 cents per pound. The price for quicksilver also has fallen off and the metal can now be obtained for $46 per flask of 75 lb. on large orders. Nickel is quoted at 40 to 45 cents for large contracts, with higher prices for small deliveries.

### The Iron and Steel Market.

The reduction in output during July and August has been less than was expected, the rate of pig iron production averaging well in excess of 25,000,000 tons a year during the two months as contrasted with an average rate of 30,000,000 tons during the preceding 12 months, and a maximum rate of 31,-000,000 tons, reached in February last. That the output was absorbed can hardly be doubted and in such a quiet market the performance was well nigh phenomenal.

The trade reached July 1 with order books almost depleted in several lines, and production in the past two months has been sustained largely by specifications upon old contracts and by new purchases. As the buying trade had accumulated large stocks in the winter and in the second quarter had been making every effort to reduce them, it is certain that the engagements in July and August were only for absolute requirements, and probably represented less than the actual rate of consumption. The situation as to stocks must be well liquidated, and the inference is reasonable that buying will improve materially in September and October. A start in this direction appears to have already been made, for representative steel interests report that their August bookings have well exceeded those for July. While it is true that July was a poor month in this respect, since so many buyers were curtailing shipments on account of inventories and closing for repairs, still the showing is favorable.

In pig iron it is not so certain the position as to stocks has been liquidated. It is possible, but by no means certain, that consumers have reduced stocks enough to balance the increase which has occurred since Jan. 1 in furnace stocks. This, of course, refers only to merchant iron, less than one-third the total output. The steel works are carrying less pig iron than three months or six months ago. The total of merchant pig iron stocks is of less consequence than the manner in which they are carried, and as to this there is some unfavorable news from the Central West, it being reported upon good authority that an important aggregate of merchant pig iron has been carried by middlemen and furnaces upon bank accommodations which are being curtailed, in some cases forcing sales at prices which are based upon exigency rather than upon cost of production.

Current buying of steel products is largely by representatives of small consumers. Structural bookings have been relatively light in the past two months, in bridge, viaduct and large building work. The railroads have been particularly light buyers. It is believed that they are "playing politics" and will not loosen the pursestrings until after the November elections.

However, it is now understood that the larger steel-car plants have steel car orders on books to carry them into December, and it must be remembered that with the new system of accounting required since July 1, 1907, by the Interstate Commerce Commission the railroads are carrying car depreciation accounts which will, irrespective of net earnings, provide large sums for the purchase of new steel cars as old wooden cars wear out.

The Amalgamated Association has declared off its strike inaugurated 14 months ago against the open-shop policy of the American Sheet & Tin Plate Company, subsidiary of the Steel Corporation. This does not affect the sheet situation materially, since the company was already operating as many sheet mills as needed, but it will effect a considerable increase of output of the tinplate, deliveries of which were much behind. The company is starting two tin-plate plants which were entirely idle on account of the strike and is recruiting forces at other mills which were short handed. This will probably increase the company's tin-plate output 30 or 35 per cent in September as compared with August, equivalent to about 20 per cent of the country's total output, and comes opportune, as the tin-plate requirements of September are heavy on account of winding up the canning season.

### Pig Iron.

At the beginning of August the pig iron markets were stagnant, but toward the close of the month buyers began to show considerably more interest. The usual small enquiry broadened out, and a few large enquirers for extended delivery appeared. There have been slight declines since our last report in nearly all prices, the most extensive being in the valley market, in which Bessemer has dropped 25 cents, basic 75 cents and foundry 50 cents. Southern has been slightly firmer in the past fortnight than it was on Aug. 1, although not quotably higher.

There are only one or two producers in the Birmingham district willing to do $11 at furnace, and that only for early delivery, other quotations being at $11.50. We quote prices f.o.b. valley furnaces as follows, freight to Pittsburgh being 90 cents: Bessemer, $15.25; basic, $13.75 to $14; No. 2 foundry, $14 to $14.25; forge, $13.35; malleable, $14.50.

### Steel.

The actual market movement in unfinished steel has been light. Prices have sagged slightly on Bessemer, while rods have declined fully a dollar a ton, owing probably to the advent of new capacity. We quote, f.o.b. Pittsburgh or Youngstown mills: Bessemer billets, $24.50; sheet bars, $25.50 to $26; open-hearth billets, $26; sheet bars, $26.50 to $27; rods, $28 to $29.

### Finished Products.

Early in August steel bars dropped definitely $1 a ton, on attractive business, selling at $1.40 per 100 lb., but $1.45 has been obtained on odd lots for early delivery, as the bar mills are still comfortably filled with specifications. The shading of nominal sheet prices has increased slightly as to galvanized, reaching $5 per ton and making the regular market on 28-gage galvanized $2.25 per 100 lb., while black sheets are occasionally shaded more than $3 per ton, which was possible a month ago. The tonnage of sheet business is large, but insufficient to engage fully the greatly increased capacity. Tin plate continues in good demand and all available capacity is in requisition. Plates and shapes, although in indifferent demand compared with capacity, are fairly well held by the large mills at the former minimum of $1.40.

Subject to shading on flat and corrugated sheets of $3 a ton for black, $5 a ton for galvanized and $1 a ton for blue annealed, we quote finished steel products as follows, f.o.b. Pittsburgh, except where otherwise stated:

Standard steel rails, $28 for Bessemer, $30 for open-hearth, f.o.b. mill, except Colorado.

Plates, $1.40 for tank quality, ¼ in. and heavier.

Shapes, $1.40 for beams and channels, 15 in. and under, zees and angles 2 x 3 and larger.

Steel bars, $1.40 to $1.45, base; iron bars, $1.40 to $1.45, Pittsburgh; $1.37½ to $1.40, Chicago; $1.37½ to $1.45, Philadelphia.

Wire nails, $1.70, base; plain wire, $1.50, base; painted barb wire, $1.70; galvanized, $2.

Black sheets, 28-gage, $2.40; galvanized, $3.50; painted corrugated roofing, $1.70 per square; galvanized, $3; blue annealed, 10-gage, $1.75.

Tin plates, $3.60 for 100-lb. cokes.

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## Electric Iron Ore Reduction in Shasta County, California

We have repeatedly referred in our columns (see especially the papers of Lyon and Bennie on pages 251 and 252 of our Vol. VII) to the pioneer work of the Noble Electric Steel Company at Héroult-on-the-Pit, Shasta County, Cal., with the electric shaft furnace for iron ore reduction. Credit for this work is chiefly due to Mr. H. H. Noble, president of the Noble Electric Steel Company, and to Prof. D. A. Lyon, who designed the electric reduction furnace and is in charge of its operation. In the early experiments Dr. Héroult, the distinguished electric-steel engineer, also participated. The place of the smelter has been called after him.

It is now reported that the progress of the work is quite satisfactory and that the operation is now passing the experimental to the commercial stage.

On July 21 a party of 22 steel men, engineers, bankers and capitalists came to Héroult from San Francisco as the guests of Mr. H. H. Noble, to inspect this first electric pig-iron plant in America. The party included Mr. S. T. Wellman, of the Wellman-Seaver-Morgan Company; Mr. Patrick Noble, of the Pacific Rolling Mills, of San Francisco; Mr. F. E. Neitzel, of the Union Iron Works, of San Francisco; Mr. S. P. Mooney, of John A. Roebling's Sons Company; Mr. Richard B. Carr, of the Carnegie Steel Company; Mr. Chas. M. Gunn, of the Columbia Steel Company, of Portland and San Francisco; Mr. Edward J. Schneider, of the American Bridge Company; Mr. R. S. Moore, of the Moore & Scott Iron Works, of San Francisco; Prof. Edward O'Neill, of the University of California, and Messrs. J. H. Meyer, A. P. Giannini, R. J. Tyson, H. D. Walker, E. E. Mead, W. A. Halstead, C. B. Morgan, A. S. Carman, C. R. Downs, G. K. Weeks, and Dr. Ferdinand Stable.

The visitors arrived at noon just in time to see the electric furnace tapped, the amount of pig iron being five tons. In the evening the furnace was tapped again. It was stated that the furnace had been running without a hitch for 11 days and that it would be kept running as long as the California Power Company could supply the required power. The furnace is being tapped every six hours. At the day of the visit there were 150 tons of pig iron piled up in the smelter yards.

The furnace has proven so successful that the erection of five more electric furnaces has been decided upon and the five transformers for the same have already been ordered.

Charcoal is used as reducing agent in the iron ore reduction and the buildings occupied by the charcoal and by-product plant are as large as the smelter itself. Mr. H. M. Soper is in charge of the same. Wood alcohol, acetic acid, tar and creosote oil are obtained as by-products of the charcoal manufacture. The Mammoth Copper Company at Kennett has now a lot of mining timber at Héroult to be treated with creosote oil as a preservative.

Four lime kilns are completed. Two are running and two more are ready to start up.

The Noble Electric Steel Company, and its president, Mr. H. H. Noble, must be congratulated on the efficient and successful way in which they are progressing in their pioneer work.

## Chicago Meeting of American Electrochemical Society.

Headquarters of the Chicago meeting, to be held on October 13, 14, 15 (Thursday to Saturday), will be at the La Salle Hotel, where, in the assembly rooms on the top floor of the hotel, sessions for the reading and discussion of papers will be held on Thursday and Friday morning. A third professional session will be held on Saturday morning at the University of Chicago.

For the afternoons various excursions will be arranged, including visits to the famous steel plants of the U. S. Steel Corporation at Gary, Ind., and at South Chicago, where a 15-ton electric Héroult furnace is in operation, and a visit to the Buffington Cement Works. On Thursday evening a subscription dinner will be held and on Friday evening a smoker.

# CORRESPONDENCE.

## Checker Work.

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—In the report in your August issue on the Fifth International Congress for Mining, Metallurgy, Applied Mechanics and Practical Geology, recently held at Düsseldorf, an account is given of the paper of Dipl. Ing. O. Friedrich on "Improvements in the Construction of Siemens-Martin Furnaces" in which he refers to the various forms of checker work which are now finding favor in Europe for use in regenerators.

We believe it will be of interest to many metallurgists in this country to know that we have recently concluded with the owners of the Scherfenberg patent a contract for the exclusive manufacture and sale in this country of the bricks illustrated in Figs. 16, 17 and 18 in your article.

These forms of checker work have very many advantages over ordinary checker brick—the heating surface is increased, there are no flat surfaces upon which the slag can deposit and finally close the gas passages, the distribution of the gases is perfectly regular and the checker work is easy to erect and perfectly rigid after erection.

For use in sulphuric acid towers and for other chemical purposes we have already supplied large quantities of these bricks made from acid-proof stoneware, and among the many other uses for which they are well adapted, the carburetion of water-gas offers a very promising field.

*New York City.*     THE DIDIER-MARCH COMPANY.

## Defects in Refractory Brick.

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—In METALLURGICAL AND CHEMICAL ENGINEERING for May, 1910, appears an article by Mr. Gilbert Rigg, of the New Jersey Zinc Company, pointing out some defects in refractories. The defects in manufacture mentioned are:

1. Insufficient purification of material.
2. Superannuated methods of manufacture.
3. Burning at too low temperature.

I would like to add to the above list of faults in manufacture the failure of the manufacturer to provide proper shapes in molding. It is common practice to cut or grind the brick into proper shape after burning. This is, in most cases, a mistake. A brick that is perfect can be ground to almost any shape with little or no damage, but can never be cut with a brick hammer or chisel without suffering in quality. This is due to what stone cutters call "opening of the material" by the jarring at-tendant on the cutting. But only a perfect brick can be ground without damage, and since perfection is a quality seldom attained it is better to make the necessary shapes and avoid grinding. The reason for this is that the surface of a brick as made in the mold is usually a better surface than can be attained after this has been removed. The pressure used in making the brick makes the surface less porous and harder than any other part of the brick. This surface is sometimes destroyed by improper burning or sudden cooling.

Another defect in making refractories consists in forcing the clay out of the machine in such a way as to cause little cracks in the corners. The bricks are afterward pressed to give them a perfect shape, and at the same time these cracks disappear; but they reappear when the bricks are used as soon as hot slag comes in contact with the brick. A number of other defects might be mentioned, but I wish to say a word for the manufacturer.

The consumer who buys "firebrick" in the open market must not be disappointed if he gets just "firebrick"; again, the consumer who orders brick of a certain chemical composition ought to be satisfied when he gets what he ordered; and, finally, when a consumer orders a first-class refractory he ought to be willing to pay for it.

Going back to objection No. 1 in Mr. Rigg's paper, "insufficient purification of material," I would change it to "improper preparation of material," and would call attention to the fact that in order to get the best results a year or more is required in the preparation of the clay, including handling it a number of times. This means a larger plant, more working capital, and consequently added cost. The consumer too often expects goods made in this manner at the same price as those which are made from clay on the same day that it is taken from the bed where nature deposited it.

Mr. Rigg's second objection is "superannuated methods of manufacture." The writer recently visited a plant where good refractories were made, as refractories go, and was surprised to see the methods, which, putting it mildly, appeared to be not the best. When the manager was asked about it he replied that the lot of brick then being made was for a firm whose custom was very desirable, and that the profit on the whole order was negligible. "But," he added, "we hope to hold their business long enough to educate them to the value of good refractories."

This is too commonly the case. The manufacturer may give good value for the money and still not give satisfaction. When the consumer and the manufacturer get together with a perfect understanding of the needs of the one and the difficulties of the other Mr. Rigg's severe indictment will be only an interesting bit of the history of refractories.

*Golden, Col.*     JOHN C. BAILAR.

## The Western Tour of the American Chemical Society.

*To the Editor of Metallurgical and Chemical Engineering:*

Sir:—Our voyage to San Francisco on the American Chemical Society's special train was a wonder trip. Ever since we left Chicago we had not a single dull day. Our train was composed of a buffet and baggage car, a diner, nine sleeping cars, and an observation car. The Santa Fé Railroad deserves our unreserved thanks. Never have I traveled on any railroad as comfortably as on the Santa Fé.

We were 110. At Chicago lunch and refreshments were offered by the Chicago Section. First stop was made at Kansas City, Mo., where some members came on. Then followed our ride through the long Kansas prairie with its agricultural richness.

The sightseeing began with Colorado Springs, Pike's Peak, Manitou, Garden of the Gods, etc. Then we passed through the desert of New Mexico, a short stop being made at Albuquerque. Indian settlements were seen everywhere with their picturesque costumes and adobe houses. The excellently oiled roadbed of the train and the fact that our locomotive was

oil-fired made it possible to remain on the balcony of the observation car almost during every stage of the trip, even in the alkali desert. It was fearfully hot, 110-120° sometimes, but the air was so dry that the heat did not incommodate us and did not even soften our collars.

The petrified forest, to which we were taken from Adamana in carriages and wagons (a distance of some 12 miles), gave us a good idea of the bleak Arizona desert. We were carted over the open, dusty prairie in the blazing sun. The samples of the petrified trees which we picked up blistered our fingers, and when after our long ride from the wonders we had seen we came back to our comfortable train everybody made a dash for the buffet car and the negro porter had a hustling time to supply drinks to our parched throats.

Next morning we awakened in a fine forest of pine trees and we were at the Grand Canyon, the most imposing spectacle I have ever seen. Some of us took horses and through a narrow trail along precipices followed the guide who led our party deeper and deeper in the hot canyon. As I am writing now I am still suffering (after about two weeks) from blisters on my unprotected sunburned hands. My wife made the trip, too, and bravely enjoyed the whole performance. What a luxury it was to have a bath in the hotel after our return from a day in the saddle.

If the petrified forest was hot, this was hotter. But the precipices make you forget the heat when your mule walks on the edge of the trail and there are a few thousand feet just below you. The clerk at the hotel described the canyon as follows: "Between hell and the canyon trail there is but a screen door."

The same night we proceeded toward California. Beautiful Redlands, more beautiful Riverside with its never-to-be-forgotten orange groves, its magnificent streets, its picturesque and comfortable Mission Hotel, giving me for the first time an instance of a city reclaimed from the desert by irrigation and transformed into a triumph of municipal æsthetics.

For the first time in my life I saw an American city which looks finished, and beautifully finished at that. From the moment you enter Riverside until you leave it, everything seems harmony and good taste and displays and proclaims high aspirations of its citizens.

Our party had already been met at the Grand Canyon by Mr. Ralph A. Gould, chairman of the local committee, welcoming us to the State of California, and just before reaching Riverside a committee of chemists from Los Angeles met our train. On the following day at Los Angeles our fellow chemists had prepared a full day of excursions and entertainments and began to give us a foretaste of the reception which was awaiting us in 'Frisco.

During the night we proceeded on our way, and early in the morning were awakened in the desert near Lang, where automobiles and a little improvised freight train took us to the borax mines, several miles between cacti and yucca plants intermingled with dried-out sagebrush and covered with alkali dust. At the borax mines of the Sterling Borax Company a big sign, "Welcome American Chemical Society," greeted us in the glistening sun. But abundance of beer cooled with ice imported from our train made us soon forget the temperature.

Strange to say, although the temperature may be as high as 110° F., it always feels very comfortable in the shade.

We left at noon never imagining that the next morning our nice comfortable train was going to be reduced to a horribly deformed mass of débris. I still wonder how we escaped. The car in which Dr. Bancroft and Mrs. Bancroft, Dr. Parsons and Mrs. Parsons, Mr. Adamson and family, Dr. Baekeland and Mrs. Baekeland, Dr. Love, Dr. Meyeda and wife were traveling was lifted up in the air, the front trucks wrenched off and tossed ahead over the wreck, so that its front end stood about 20 ft. high in the air, ready to topple over in the ravine, but held back I do not know how. One car—the dining car—was shot ahead bodily over the upturned locomotive and the buffet car was shot into the sand bank and was twisted like a piece of cardboard, while the splinters and wreckage were shot high up into the barren hill. Our baggage was lost in the wreckage, and several of the party were digging lustily away in the sand bank.

The locomotive, with its wheel in the air, was buried with its front part into the sand, and the emptying oil tanks made a river of oil, the rush of which made me first suppose that our car had rolled into the stream. Afterward the smell of the oil made us think the gas pipes had burst. All this, of course, while we were still prisoners in our car and before we had succeeded in breaking out. The engineer, whose reckless driving around the mountain curve had caused the accident, was pinned underneath, together with the fireman, both dead. Dr. Whitney managed to rescue the conductor, who was in a much disturbed condition and was buried in one of the wrecked cars. The crew, conductors, brakemen, porters and everybody connected with the train behaved admirably; nobody seemed unduly excited and everybody did the right thing at the right time and tried to help others. Several were injured, but made slight of their wounds or bruises.

The ladies of our party, too, were very self-possessed, although most of them had scant time to dress. There was not a complaint, not a sign of emotional weakness in our whole party. The last seven sleeping cars had hardly been damaged, and some had not even left the track. The landscape where all this occurred was one of those large California ranches with the Sierra in the distance, and our train left the track at a curve around a hill known as Rocky Point, near the Salinas River, half way between King City and Metz.

The news soon became known by telephone. Cowboys came galloping over the plain. Mexican Indians and Japanese came from the ranch. Then from the next city came automobiles rushing at full speed between cacti and sagebrush. Some thoughtful people brought basketsful of excellent fruit. Surgeons and nurses arrived in automobiles from Salinas, and before long a rescue train arrived to enable us to continue our voyage.

A wreck train and crew started immediately to work—all Mexican Indians and Japs—to build a new track and remove the wreck, and I heard the foreman telephone that the track would be clear within six hours.

As to our reception in San Francisco I shall not attempt to describe it. A splendidly managed hotel is the St. Francis, where we all were housed and where all meetings took place, and from the moment we arrived until we left, our generous, cheerful California friends heaped festivities and entertainments upon us without intervention.

We in the East cannot realize what an enormous country we live in, and anybody who has not visited the Pacific Coast cannot have the proper conception of the United States. And what big-hearted, enthusiastic fellows one meets here; no weaklings, no drones, no pessimists here. Whoever beholds the new San Francisco rebuilt in no time after a most disastrous calamity which would have discouraged any city in the Old World can understand the latent power, the constructive genius, the executive abilities of these empire builders of the West.

Everything seems big, generous here. From the giant trees in the forests and the endless wheat fields and orchards to the very men and women. And then our trip to Portland and Seattle, through those virgin forests, with trees towering as high as church spires, rushing foamy torrents, snowclad mountains, and now over Vancouver and the Canadian Pacific in the heart of the Canadian Rockies, mountains and glaciers and forests which are large enough in size and in extent to build several Switzerlands and several Tyrols, endless unsettled portions of the beautiful earth eagerly awaiting sturdy men to take advantage of its bountiful resources, while our race is degenerating in congested, vile cities.

*Glacier House,*                         X. Y. Z.
      *Glacier, B. C., Canada.*

## The Effect on the Solubility of Gold When Ore Is Crushed Between Iron Surfaces.

### By J. M. Tippett.

There are several types of machines commonly used for comminuting ores, each of which has its friends, some favoring the stamp, others the chilian mill, and still others the tubemill. A combination of the stamp and tubemill is frequently used, or of chilian mill and tubemill. Regardless of which combination is used, the main idea is to comminute the ore to a desired degree of fineness at the lowest possible cost.

A general impression has prevailed that grinding to a certain degree of fineness is all that is necessary in order to obtain the best extraction in cyanide solutions, but, speaking from an experimental point of view, I have found that fine grinding by attrition between two iron surfaces, such as the bucking-board and muller or the coffee-mill grinder, gives unsatisfactory results, and is apt to mislead one experimenting on an ore which would give better extraction results if it was ground to the same degree of fineness between flint surfaces.

When experimenting on the Portland Gold Mining Company's chlorination tailing dump in 1905 I found that grinding this material between two iron surfaces put the gold in such a condition that it was not readily amenable to solution in potassium cyanide. The dump material was 14-mesh and contained an average gold value of $1.60 per ton.

Leaching tests were first tried on lots ranging from 2 lb. to 2 tons. This soon proved unsatisfactory owing to the fact that much of the gold was encased in the coarser particles of the tailing, and the extraction never exceeded 50 per cent. Crushing to 20-mesh and 30-mesh gave no better results. Grinding in an iron mortar with cyanide solution, or grinding on a bucking-board so that all would pass 200-mesh, using a strong cyanide solution and long agitation, also proved of no avail. At the time this seemed rather strange considering the extreme fineness to which the ore had been ground. No better extraction was gained by grinding the tailing to 200-mesh than by treatment at 14-mesh just as it came off the dump.

Finally a 16-gal. beer barrel was fitted up as a tubemill with a central shaft, at one end of which was a pulley belted to the main lineshaft in the concentrator. This crude device was filled half full of pebbles, 50 lb. of tailings and sufficient cyanide solution and allowed to grind for several hours. Immediately the extractions rose to 70 per cent and 80 per cent.

The conclusion arrived at regarding the poor extraction obtained when the tailing was ground between iron faces was that the gold particles possibly became coated or glazed with a film of metallic iron, which made it impossible for even strong solutions of potassium cyanide to attack them.

At about the same time Mr. Herbert W. Fox, superintendent of the United States Reduction & Refining Company's works at Colorado City, was experimenting on their tailing dump, which contained the same class of material as our own, with the result that their cyanide plant was built and put into commission a short time before the Portland company's mill was completed. Both plants are using tubemills with silex lining for grinding the tailings treated in the cyanide plants.

To further investigate whether comminuting ore by means of attrition between two iron faces really had an effect on the solubility of the gold contained, a large quantity of $20 roasted ore was subjected to a series of tests. The extraction on this ore, ground to 14-mesh, by treatment in a chlorination barrel with a normal charge of chemicals (10 lb. of bleaching powder containing 35 per cent available chlorine and 27 lb. of sulphuric acid per ton of ore) was 90 per cent to 92 per cent. The same ore ground in a silex-lined tubemill in cyanide solution gave an extraction of 94 per cent to 96 per cent.

Portions of this same ore which gave the above extractions were then taken and subjected to a series of tests, after having been ground to 100-mesh, as follows: for the first series the portion was ground in a coffee-mill grinder; for the second, on a bucking-board, while the third was ground in a small tubemill. Each portion was then panned and the concentrate eliminated, thus reducing the gold content of the portion to be treated, as shown by the assay of the heads in each series. Taking out the coarse gold particles by concentration after grinding and before the application of chemicals should have helped the extraction, but as shown in the series in which the ore was ground between iron faces, it did not aid extraction, and if the coarse gold had been left in the ore the extraction would have been still poorer.

#### Series No. 1.

*Ore ground in a coffee-mill grinder. Head after panning assayed 0.68 oz. gold.*

(a) Four hours' treatment by agitation in 0.2 per cent chlorine water solution made acid with 5 lb. sulphuric acid per ton of ore; proportion of solution to ore, 2:1, or 8 lb. chlorine per ton of ore; after treatment the solution contained 0.07 per cent chlorine, showing a consumption of 5.2 lb. of chlorine per ton of ore. Tailing assayed 0.52 oz. gold. Extraction, 23.5 per cent.

(b) Conditions the same as in (a) except 10 lb. of sulphuric acid were used instead of 5 lb. After treatment the solution contained 0.05 per cent chlorine, showing consumption of 6 lb. chlorine per ton of ore. Tailings assayed 0.35 oz. gold. Extraction, 48.5 per cent.

(c) Conditions same as in chlorination barrel on the basis of 10 lb. of bleaching powder containing 35 per cent available chlorine, and 27 lb. sulphuric acid per ton of ore. Agitation for four hours. After treatment there were 1.06 lb. of available chlorine per ton of ore. Tailing assayed 0.61 oz. gold. Extraction, 1 per cent.

(d) Four hours' treatment by agitation in a 2-lb.-per-ton cyanide solution; proportion of solution to ore, 3:1; protective alkalinity, 0.35 lb. lime. After treatment the solution contained 1.8 lb. cyanide per ton. Tailing assayed 0.18 oz. gold. Extraction, 73.5 per cent.

(e) This was made an extreme case. Forty pounds of bleaching powder, containing 35 per cent available chlorine, and 110 lb. sulphuric acid were used per ton of ore. Agitation for four hours. Tailings assayed 0.04 oz. gold. Extraction, 94.1 per cent.

Cost of bleaching powder per ton of ore.......$0.80
Cost of sulphuric acid per ton of ore.......... 1.10
———
Cost per ton of ore for chemicals...............$1.90

#### Series No. 2.

*Ore ground on a bucking-board. Head after panning assayed 0.78 oz. gold.*

(a) Four hours' treatment by agitation in a 0.285 per cent chlorine water solution made acid with 5 lb. of sulphuric acid per ton of ore. Proportion of solution to ore, 2:1. After treatment the solution contained 0.132 per cent chlorine, showing a consumption of 5.72 lb. chlorine per ton of ore. Tailing assayed 0.36 oz. gold. Extraction, 53.8 per cent.

(b) Condition the same as in (a) except that no sulphuric acid was used. After treatment the solution contained 0.158 per cent chlorine, showing a consumption of 4.68 lb. chlorine per ton of ore. Tailing assayed 0.44 oz. gold. Extraction, 43.5 per cent.

(c) Treatment the same as in chlorination barrels on the basis of 10 lb. of bleaching powder containing 35 per cent available chlorine and 27 lb. sulphuric acid per ton of ore. Agitation for four hours. After treatment the solution contained 0.061 per cent chlorine, showing 1.22 lb. chlorine per ton of ore still available. Tailing assayed 0.67 oz. gold. Extraction, 14.1 per cent.

(d) Four hours' treatment by agitation in a 4-lb.-per-ton cyanide solution; proportion of solution to ore, 3:1; protective alkalinity, 2 lb. lime. After treatment the solution con-

tained 3.5 lb. potassium cyanide per ton. Tailing assayed 0.12 oz. gold. Extraction, 84.6 per cent.

### Series No. 3.

*Ore ground in a small tubemill. Head after panning assayed 0.64 oz. gold.*

(a) Four hours' treatment by agitation in a 0.153 per cent chlorine water solution made acid with 5 lb. sulphuric acid per ton of ore. Proportion of solution to ore, 2:1, or 6.12 lb. chlorine per ton of ore. After treatment the solution contained 0.09 per cent chlorine, showing a consumption of 2.52 lb. chlorine per ton of ore. Tailing assayed 0.04 oz. gold. Extraction, 93.7 per cent.

(b) Treatment the same as in chlorination barrels on a basis of 10 lb. of bleaching powder containing 35 per cent available chlorine, and 27 lb. sulphuric acid, per ton of ore. Agitation for four hours. Tailing assayed 0.07 oz. gold. Extraction, 89 per cent.

(c) Agitation for four hours in a 2-lb.-per-ton cyanide solution; proportion of solution to ore, 3:1; protective alkalinity, 0.2 lb. lime. After treatment the solution contained 1.8 lb. cyanide per ton. Tailing assayed 0.06 oz. gold. Extraction, 90.6 per cent.

While it is probable that comminution on a commercial scale in the Chilian or Huntington mill, or grinding pan, would not produce such a noticeable effect on the extraction as is shown in an experimental way, using the bucking-board or coffee-mill grinder, I am inclined to believe that grinding effected by attrition between two iron faces is likely to put gold in such a condition that it is not susceptible to the action of cyanide solutions, and that this condition is more marked than when grinding to the same degree of fineness between flint surfaces.

*Portland Mill, Colorado Springs, Col.*

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## The Fuel Requirement of the Rotary Cement Kiln.

### By W. S. Landis, M. S.

The purpose of the present paper is to discuss from the theoretical and the practical standpoints the the fuel requirement of the rotary cement kiln, more particularly under the conditions existing in the Lehigh cement region. Only minor changes, however, are required to adapt the whole discussion to the operating conditions of any other region into which the rotary kiln has made its way.

In the Lehigh district cement rock (an argillaceous limestone) or cement rock and pure limestone are ground very fine and fed into the kiln dry, coming out in the form of a sintered mass technically called "clinker." Five hundred and sixty pounds of the raw material, called "mix," are fed to the kiln to make a barrel (the unit weight) of clinker, weighing 380 lb.

In the region in question the mix will average 33 per cent, or 188 pounds per barrel of clinker, of carbon dioxide, existing in the raw material as calcium carbonate. The only reactions taking place in the charge in the kiln are the driving off of the carbon dioxide and the sintering together of the rest of the ingredients to form the clinker. The mix is artificially dried before fine griding, so that here we are not even concerned with the driving off of water from it. (Where clay is used in the charge the dehydration must be taken into account if done in the kiln.)

The calculation of the heat requirements of these reactions is quite as simple as the reactions themselves. The heat of decomposition of calcium carbonate is 1020 pound-calories per pound of carbon dioxide, so that to decompose the carbonate present requires $188 \times 1020 = 191,760$ pound-calories. The sintering of the residue of ingredients is really the chemical union of the silica, lime, and alumina, etc., giving out heat in the reaction.

By the combustion of a given weight of mix with a coal of known calorific power in a bomb calorimeter the author has evaluated the heat of formation of the clinker as 200 pound-calories per pound. This figure is not quite as accurate as it is hoped will eventually be attained, as not all the difficulties of performing this reaction perfectly in the bomb have successfully been overcome, but its limit of error is well within that of the more commonly accepted thermo-chemical data, and it will well serve the purpose of the present paper. The formation of clinker will then generate $380 \times 200 = 76,000$ pound-calories.

The net heat absorbed in the kiln per barrel of clinker, to be supplied from external source, is:

Heat of decomposition of carbonates..........191,760 lb.-cals.
Heat of formation of clinker................. 76,000 "

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Net heat absorbed ..................... 115,760 "

From a number of calorimeter determinations of the calorific powers of the long flame bituminous coals used in the Lehigh region for firing the kilns this figure was found to average 7400 pound-calories per pound of coal (practical or lower calorific power). Our kiln will therefore require a minimum of 15.7 pounds of coal to produce the reactions necessary for clinker formation irrespective of its kind and size.

It must be remembered, however, that the dissociation of calcium carbonate requires a temperature of 700° to 800° C., depending somewhat on the partial pressure of the carbon dioxide in the atmosphere of the kiln, and also that the formation of the clinker only takes place at temperatures between 1200° and 1300° C. Unfortunately, we have not up to the present attained that perfection of metallurgical apparatus so that we can maintain such temperatures in a continuously working apparatus without considerable losses of heat. Our figure for minimum coal requirement which we have just calculated, therefore, has but little significance to the kiln man operating under industrial conditions. The inevitable losses which occur in the production of such high temperatures on the large scale demanded bring up the fuel consumption to many times this theoretical figure.

Taking up these losses in detail in the light of a large number of heat balance sheets which the author has made on kilns varying from 60 to 135 feet long, operated under various superintendents, and always under actual working conditions, the following facts and conclusions have presented themselves:

In a kiln burning pulverized bituminous coal of 70 per cent total carbon and a mix containing 33 per cent carbon dioxide, perfect combustion should result in a chimney gas of the approximate composition (dry): carbon dioxide 36 per cent, nitrogen 64 per cent by volume. Both the coal and the mix being dried before grinding, the only moisture that would accompany this gas would be that from the combustion of the hydrogen in the coal. (This composition was calculated from the coal consumption of 65 pounds per barrel of clinker, which we will later arrive at.)

In no case has the actual chimney gas analyzed anything like this figure, when the samples were taken under the actual operating conditions. An average of these analyses (dry) taken on mills in various parts of the region was carbon dioxide 14.5 per cent, oxygen 9.5 per cent, nitrogen 76 per cent, showing the presence of large excess of air. This air gets into the kiln through at least two places: one intentionally through the nozzle feeding the coal into the kiln, the other through leaks around the lower end of the kiln and through various sight and poke holes invariably left open.

The air entering through the burner is under direct control of the operator; by means of it he regulates the length and character of the flame. No attempt seems to be made to control the leakage, as very few of the plants are equipped for the analysis of stack gases and the interpretation of the results. The height and sizes of chimneys seem to have been a matter of guess; they are all too high, and poor regulation of drafts is gotten by opening a door leading to the outside at their base, so admitting cold air.

The enormous amount of heat carried out through the chimney of a cement kiln even with perfect combustion would cause one to suppose that in the present financial state of the industry this item was closely watched. Actual kilns burning from 80 to 100 pounds of coal per barrel of clinker, discharging the products of combustion into the stack at 500° C. (average of actually measured temperatures) lose up the chimney 130,000 pound-calories, for the lower fuel consumption with perfect combustion, to 275,000 pound-calories for the higher fuel consumption with excess air such as in the average analysis given above. These figures have been taken from balance sheets of actually operating kilns, the first figure from a 135-foot kiln using 84 pounds of coal and the second figure from a 60-foot kiln using 100 pounds of coal per barrel of clinker.

In terms of pounds of coal these figures represent 17 and 37 pounds respectively, a difference of 20 pounds chargeable to a lengthening of kiln and elimination of excess of air. The excess air in the shorter kiln carried out 110,000 pound-calories, leaving to the advantage of the longer kiln 35,000 pound-calories. In terms of pounds of coal the fuel consumption of the smaller kiln was 15 pounds too high because of excess air in products of combustion, and 5 pounds too high because of the kiln being too short for efficient heat regeneration.

Using the actual minimum fuel consumption we shall calculate later, perfect combustion without excess of air, and a gas temperature of 500° C., the chimney loss would be about 100,000 pound-calories, representing a coal consumption of 13.5 pounds for this item.

A curious coincidence in connection with the thermal study of the kilns as actually operated was the fact that the temperature of the gases leaving the kilns, irrespective of the fuel consumption and length of the kilns, was in all cases very close to 500° C. Actually on a 60-foot kiln 490°, 100-foot kiln 525°, and 125-foot kiln 510° C. At first glance it looks as if the length of the kilns had but little to do with the extraction of heat from the gases passing through them, but really such is not the case. This temperature is dependent not only on the extraction of heat from the gases, but also on the fuel consumption, amount of air used in combustion, and in radiation losses of the kiln. It was just a coincidence that in all cases studied these items always balanced so as to give nearly the same temperature.

Actual data has not been published as to the running of the new 260-foot kiln on the Hudson, but it has been hinted that the stack temperature is close to 300° C. It has been mathematically proved that the most economical temperature as far as the chimney is concerned is to have the gases enter at 300° C. There is nothing to be gained by introducing the gas into the chimney at 500° C. The heat in the gas equivalent to the difference in temperatures of 500° and 300° C. had better be used for drying purposes. With gases at 300° instead of 500° C. our coal requirement for the chimney could be cut down from 13.5 pounds to 8 pounds per barrel, of course, only if the heat equivalent to the difference in temperature was intercepted in the kiln.

The loss of heat in the hot clinker leaving the kiln is a large item. The clinkering temperature is absolutely fixed so that practically all kilns discharge clinker at the same temperature, 1050° C. for this region. The specific heat of clinker is 0.207 + 0.000019t. The heat in a barrel of clinker at 1050° C. is 90,500 pound-calories, equivalent to 10.5 pounds of coal.

Practically all American kilns discharge this hot clinker to a conveyor and run it to cooling towers, taking extra precautions to lose all the heat contained. Abroad it is run through an under-cooler, giving up two-thirds to one-half its heat to the air entering the kiln. Such regeneration easily results in a saving of from 5 to 7 pounds of coal, an item well worth considering where we are turning out millions of barrels of cement annually. The cost of an under-cooler is small in comparison with the saving that results from its use.

Finally we have to consider the item of radiation and conduction loss. Numerous measurements made of the temperature of the outside of kilns of all sizes have failed to lead to any concordant results as far as calculation of the radiation loss is concerned. It seems as if the complex nature of the surfaces in the average kiln-room which receive the radiant heat so complicate the calculation that up to the present a direct estimation of this loss is not possible.

One thing is certain, the surface of the kiln will not radiate more heat than it receives by conduction through the lining. If we can back up the shell with a suitable heat insulator and then inside of that put the alumina bricks, or other lining used, we are going to cut down the radiation losses of the kiln considerably. Magnesia or alumina bricks are too good heat conductors to rest directly against the shell of the kiln for economical operation. Years ago an asbestos layer was tried in just such a composite lining as advocated, but its yielding character precluded mechanical stability.

What is wanted is a more firm material of low heat conductivity, and it has occurred to the author that bricks of infusorial earth such as the "moler," which have been described repeatedly in this journal would well fill this qualification. Tests made in the author's laboratory have shown an abnormally low heat conductivity for these brick; they will stand up sufficiently rigid to temperatures of 700° to 800° C. The great shrinkage can be taken care of by burning them at a temperature slightly higher than they will afterwards be called upon to withstand. The regular refractory lining of alumina bricks can be laid right against the moler bricks. I firmly believe the present heat losses by radiation could be cut down one-half by the use of such a composite lining.

Some radiation and conduction losses taken from heat balance sheets of various kilns are here reproduced:

60-ft. kiln, old lining..........................268,000 lb.-cals.
100 "    "    new lining .......................176,000    "
135 "    "    .................................255,000    "

The figure on the 100-foot kiln is the lowest value ever found by the author for this loss, and represents the nearest approach to perfection in a single-material kiln lining. It corresponds to a coal consumption of 23.5 pounds. A composite lining as described should reduce the loss to 100,000 lb.-cals., a coal consumption of 13.5 pounds per barrel of clinker.

And now in conclusion, to sum up the coal consumption of our kilns, we should have, conditions as indicated:

Reactions ............................................. 15.7 lbs.
Chimney loss, 500°, combustion perfect............... 13.5  "
Clinker loss, no regeneration........................ 10.5  "
Radiation and conduction loss, ordinary lining....... 23.5  "
                                                      ————
          Total.................................... 63.2  "

These figures represent conditions as actually met with in one kiln or another, though not all on the same kiln at the same time. If, however, they can be attained individually, there is no reason why under intelligent supervision all the conditions which originally assured them should not be applied simultaneously to the same kiln. The nearest approach met by the author in practice to the attainment of this coal consumption was 71 pounds, though unfortunately in that kiln combustion was not quite complete and the lining was old and thin. The average consumptions varied from 85 pounds for a 135-foot kiln to 100 pounds and over for a 60-foot kiln.

If we go a step further and embody the reasonable possibilities mentioned in the body of the paper our coal consumption should be:

Reactions ........................................... 15.7 lbs.
Chimney loss, 300°, perfect combustion............... 8.0  "
Clinker loss, half heat regenerated.................. 6.0  "
Radiation and conduction loss, composite lining...... 13.5  "
                                                      ————
          Total.................................... 43.2  "

I expect to see in the near future in this region cement burned with less than 50 pounds of coal per barrel. Industrial

conditions are forcing the small concerns, who cannot afford the necessary experimental work on a large scale, out of business. The larger concerns have just awakened in the past year to the great saving to be made in the cost of manufacture by an intelligent supervision of the fuel consumption and kiln design. The rotary kiln is far from perfection and our foreign friends, realizing its great limitations, are even now at work on a new type of kiln which will bring the fuel consumption as low as 35 pounds per barrel.

*Lehigh University, South Bethlehem, Pa.*

## Hardness Tests on Alloys of Nickel and Copper with Electrolytic Iron.—II.

By G. A. Roush.

In a previous paper[1] the writer has discussed the effects of the addition of nickel and of copper to electrolytic iron, and the present paper is a continuation of this investigation, giving the effects of the addition of these elements together to iron, it being a part of the extended study of electrolytic iron alloys that is being carried out in the Chemical Engineering Laboratories of the University of Wisconsin, under grant from the Carnegie Institution.

In view of the results obtained from the nickel and copper series of alloys with electrolytic iron, it is of interest to note the results of combining both metals in one alloy. This particular part of the investigation is of interest in two ways: first, in view of the possibility of the hardening properties of the two metals being more or less additive so that the copper will increase the already high values obtained with the nickel alloys, and, second, if the copper does not actually detract too much from the value of the nickel additions, the probability of being able to substitute the new commercial alloy, Monel metal, in place of the more expensive nickel as the addition agent.

With this in view, alloys were made, in the same way as before, with from 2 per cent to 20 per cent of Monel metal and tested for hardness by means of the scleroscope. On account of the close agreement that was noted between the added quantities and the actual analysis in the previous series and the fact that Monel, being a commercial alloy, is subject to slight variation, it was not thought necessary to make any analyses of these alloys, but to simply record them according to the proportions of Monel that had been added to the melt. In the calculation of the ultimate composition of the alloys the average analysis of the Monel was taken as showing two-thirds nickel and one-fourth copper, the impurities not being taken into consideration since they could not be controlled.
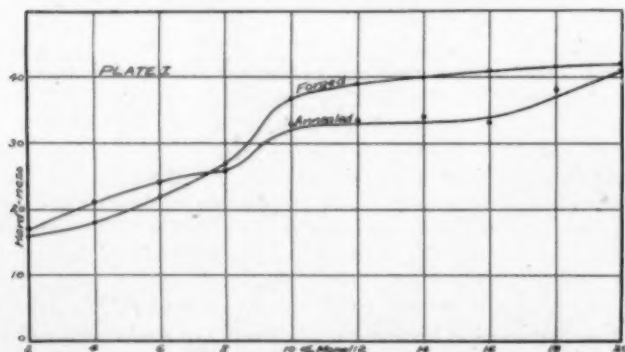
The hardness curve for the forged samples rises rather



FIG. I.—HARDNESS OF FORGED AND ANNEALED MONEL ALLOYS.

rapidly up to 10 per cent, and then more gradually to the end of the series. In the annealed samples the rise up to 10 per cent is not quite so abrupt, and from 10 per cent to 16 per cent is practically a straight line; from 16 per cent to the end of the series the rise is about the same as that below 10 per cent.

[1]This journal, August, 1910

The variation of the readings from the mean is less in this series than in either the nickel or copper series. Up to 7½ per cent the curve for the annealed samples lies above that for the
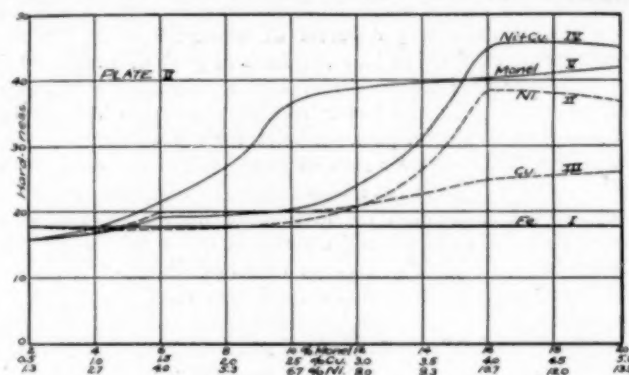


FIG. 2.—COMPARISON CURVES FOR FORGED ALLOYS.

forged samples, and the indications are that the curves would cross again slightly above 20 per cent.

The results are given in Tables I and II, both being plotted together in Fig. 1.

TABLE I.—HARDNESS OF FORGED MONEL ALLOYS

| Per cent Monel. | Number. | Maximum. | Minimum. | Average. |
|---|---|---|---|---|
| 2 | 1 | | | 16 |
| 4 | 3 | 18 | 18 | 18 |
| 6 | 1 | | | 22 |
| 8 | 3 | 28 | 26 | 27 |
| 10 | 3 | 42 | 34 | 37 |
| 12 | 3 | 40 | 37 | 39 |
| 14 | 1 | | | 40 |
| 16 | 3 | 42 | 40 | 41 |
| 18 | 2 | 43 | 40 | 41½ |
| 20 | 2 | 43 | 41 | 42 |

TABLE II.—HARDNESS OF ANNEALED MONEL ALLOYS.

| Per cent Monel. | Number. | Maximum. | Minimum. | Average. |
|---|---|---|---|---|
| 2 | 2 | 17 | 17 | 17 |
| 4 | 3 | 21 | 21 | 21 |
| 6 | 2 | 25 | 23 | 24 |
| 8 | 3 | 28 | 24 | 26 |
| 10 | 2 | 34 | 32 | 33 |
| 12 | 2 | 34 | 33 | 33½ |
| 14 | 3 | 40 | 31 | 34 |
| 16 | 3 | 41 | 31 | 33 |
| 18 | 3 | 42 | 35 | 38 |
| 20 | 3 | 41 | 40 | 41 |

In Figs. 2 and 3 are given the comparisons between the single additions of nickel and copper, and their addition together. First (I) the base line for iron is given in the forged condition at 18 and in the annealed condition at 14. Along with this are plotted the variations from the iron value caused by the addition of different amounts of nickel and copper (II and III). These values are then combined to form a fourth curve (IV), which is the result that might be expected if the hardening properties of the two metals when added together are strictly additive. The fifth curve (V) is the result actually obtained from the additions as stated, in comparison with what is to be expected from curve IV.

In the forged condition the hardness does not reach quite such a high value as might be expected, if the hardening powers of the two metals were additive, but the maximum value is reached at a much lower percentage, so that the small difference in hardness is more than balanced by the economy of the smaller addition. In the annealed samples the hardness is much above anything that could be predicted from the results

obtained from the single metals, the difference being particularly pronounced between 8 per cent and 16 per cent.

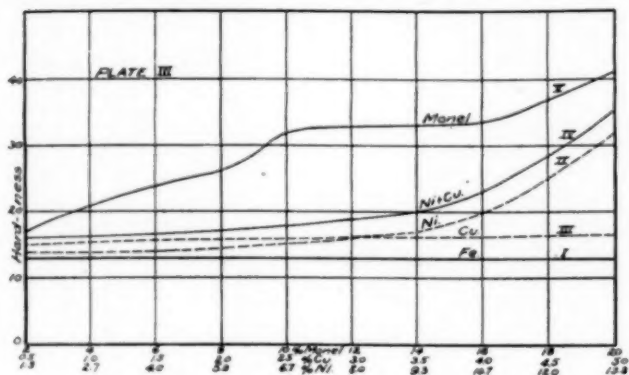The comparison of the nickel and Monel curves shows sev-



FIG. 3.—COMPARISON CURVES FOR ANNEALED ALLOYS.

eral points in favor of the Monel. The maximum available hardness in both the forged and annealed condition, without the addition of excessive quantities of Monel, is at about 11 per cent or 12 per cent against 16 per cent for the pure nickel, the maximum values in both cases being practically the same. This leaves a large margin in favor of the Monel, a smaller quantity of a cheaper material giving the same results as a larger quantity of a more expensive material.

As can be seen from Curves I and II, in Figs. 2 and 3, the addition of pure nickel to iron gives no appreciable increase in hardness below 6 per cent, while the addition of the same quantity of Monel gives a marked increase in the hardness, and it is within this range that most of the nickel-steels for construction work are found.

It is possible that some commercial use may be made of the fact that at about 7½ per cent Monel the hardness of the material is the same in both the forged and the annealed condition. With the pure nickel it is necessary to go to 21 per cent to obtain similar conditions.

*Chemical Engineering Laboratories,*
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*Madison, Wis.*

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**The University of Pittsburgh** is mailing copies of its *Bulletin*, Vol. 6, No. 7, giving a description and collection of data on the School of Engineering, with special reference to the Co-operative System. The 52-page booklet (June 15, 1910) contains notes on the equipment, requirements for admission and synopsis of courses for the following departments of the engineering school: civil, mechanical, electrical, chemical and sanitary. The degree of B. S. is awarded. The "co-operative plan of engineering instruction" is somewhat new and is being tried out by the university in order to take advantage of the unusual opportunities offered by the great industries of the Pittsburgh district for practice shop training to supplement the necessarily more theoretical work in school. Several of the large industries of Pittsburgh have made special arrangements to give practical training to the technical graduate and better fit him for a position in the organization. The Westinghouse Electric & Manufacturing Company, for instance, has a well-organized post-graduate two-year course. The co-operative plan of the university makes use of these and similar facilities. It has developed "a plan whereby the student, while spending in school the amount of time usually devoted to instruction in our best engineering institutions, will work four terms of three months each, in the engineering industries of the Pittsburgh district. By this plan the student gets the usual theoretical course and in addition 12 months of practical work, all in a space of four years, the school work being arranged so that successive groups of students will furnish continuous service to the employer."

## The Application of the Grog in Firebrick Manufacture.

### BY GILBERT RIGG.

In fireclayware the grog plays two important parts. Frequently it is more refractory to heat than the bond clay, and serves, therefore, to make the whole mass more refractory. Again, it forms a skeleton tending to hold the mass rigid and four-square, diminishing shrinking and preventing irregular shrinkage or deformation.

The type of firebrick which consists of a highly refractory grog and a less refractory bond clay has many points to recommend it, especially for moderate temperatures (say, up to 1300° C.), and for exposure to deleterious vapors. For grog we may use one of the highly refractory flint clays of a non-shrinking kind, or if it shrinks on burning it must be thoroughly burned before being incorporated in the mass. The bond clay should be highly plastic, softening at cone 25 or thereabouts and burning dense at 1000° C. From such ingredients an exceedingly dense and hard brick can be made, especially if the burning is carried out at a sufficiently high temperature to vitrify the bond.

The chemical composition of the grog should be such as to render it inert both chemically and physically. Pyrite and similar fluxes are highly objectionable. So also is free silica. Silica has the property of expanding on burning and in doing so will rupture the bond as the following experiment shows:

A certain bond clay of high plasticity and good quality was selected, made up with its own weight of a grog composed of the same clay burnt. Another lot of the clay was mixed with its own weight of coarse quartz sand of approximately the same size as the grog.

Specimens of both masses were burned at 1000° C. for 24 hours.

The clay and grog mass had a tensile strength of 322 lb. per square inch and the clay and sand mass 105 lb. per square inch. The former shrank 3.2 per cent on drying and the latter 2.1 per cent. On burning the grog mass shrank an additional 1.4 per cent, while the sand mass expanded again, the final shrinkage being only 1 per cent instead of the 2.1 per cent found on drying. This expansion of the sand grains strained and weakened the bond and reduced the breaking strain accordingly. By using more of the sand a mass was obtained that could be crumbled between the fingers after burning.

The question of the value of the determination of the breaking strain as an indication of density and compactness in a refractory mass deserves a short digression. From my own experience I believe that in judging the compactness of masses composed of a given clay, whose breaking strain is known, and equal quantities of different grogs, it serves as a valuable indication. Clearly the addition of comparatively coarse-grained, non-plastic material to a clay mass cannot increase its resistance to rupture under tension. All experiments go to show the contrary, just as occurs with concrete. For example, a certain bond clay, which burnt alone had a breaking strain of 326 lb. per square inch, fell to 213 lb. when mixed with its own weight of a burnt flint clay crushed through a 10-mesh screen.

The resistance to rupture of such a mixture of clay and grog depends upon the compactness of the mass, in other words, upon the degree of closeness with which the constituents adhere. Any separation between grog and clay, or through the particles of grog or the interstitial clay, at an angle to the direction of tension, will lower the breaking strain, and it is just such planes of separation or shrinkage cracks which give destructive vapors and fluxes their chance to enter the mass.

The breaking strain serves to measure the degree of coherence of the mass and in consequence supplies useful information as to the most suitable temperature of burning. When the breaking strain reaches a maximum it is certain that the mass is knit together as closely as the material it is composed of is

capable. Vitrified masses are usually exceedingly strong. It serves also to check the duration of burning. Some clays continue to gain in strength when kept for a week or more at the same temperature.

Then we have the question of shrinkage. The determination of the shrinkage of a mass is sometimes misleading. Some masses have a low shrinkage on account of their chemical composition. In others the low shrinkage is only apparent and is due to the internal rupturing of the mass by a mass of recticulated hair-cracks. The low breaking strain betrays this condition at once.

The application of the grog in such a manner as to give the greatest possible density in the mass presents certain problems of interest.

In the first place it is obvious that the individual grains should neither shrink nor crack. Then their shape should be such as to encourage close packing and interlocking, and the question of size needs consideration in connection with the work to which the bricks are to be put.

It is highly desirable that the grog should not shrink nor crack either during burning or during service. Yet it is not unusual to find firebricks with round grains of flint clay from ¼ in. to ½ in. diameter, cracked and ready to fall out. Some flint clays, though shrinking very little, if at all, have a marked tendency to crack and break up on heating into small, angular and exceedingly hard fragments, forming an excellent grog. When such flint clays, however, are worked into the mass green, in pieces larger than they would naturally break into on heating, they will split up inside the mass. No bond can possibly get into the cracks so formed, and such a grog becomes a source of weakness rather than strength.

Rounded grains have the further drawback of not packing well. Angular fragments pack much closer into one another, and for this reason are to be preferred. A tightly packed, non-shrinking, non-cracking grog tends to give a dense brick and what is highly important a brick that is true in shape. The more permanent the skeleton the truer will be the body.

The question of sizing is an important one. Where the grog is of coarse grain, the mesh work of bond clay will be coarse and the shrinkage on burning will cause the bond to open in a series of cracks.

Such ware is porous, but under certain circumstances this may be useful, as such goods expand and contract but little as a whole. In gas retorts, for instance, this plan is followed.

But in firebricks that have to withstand slags and destructive vapors, this plan is bad. What is needed in such a case is to get the grog skeleton as closely and densely packed as possible so as to minimize as far as may be the tendency of the bond to open.

In working out this question it occurred to me that useful results might be obtained by taking a hint from concrete mixing. In the latter operation, motives of economy make it important to use no more cement than is necessary to give the strength required. With properly graded stone, gravel and sand a considerable economy can be obtained over haphazard sizing and mixing.

The principle involved is that of filling the space as completely as possible with the stone, etc. If all the fragments are of the largest size used, the unfilled space is at a maximum. By adding the next size of material the spaces between the large pieces are partly filled. With yet another size more space still is occupied, and so on until the amount of cement is reduced to a minimum.

It can be shown that if the materials are graded into a number of different sizes by screening (mechanical analysis), then "concrete which works the smoothest in placing and gives the highest breaking strength for a given percentage of cement, is made from an aggregate whose mechanical analysis, taken after mixing the sand and the stone, forms a curve approaching that of a parabola, with its beginning at zero co-ordinates (o) and passing through the intersection of the curve of the

coarsest stone with the 100 per cent line—that is, passing through the upper end of the coarsest stone curve."

The foregoing passage occurs on page 195 of Taylor and Thompson's "Concrete, Plain and Reinforced." In succeeding paragraphs of that work a simple method of drawing the curve for any given set of sizes is shown.

I have made some trials of the application of this principle to grog-clay masses, with interesting results.

Starting out with a grog composed of well-burnt fireclay, crushed through a 10-mesh screen, the material was first separated on a series of screens into sizes. From these sizes a curve was calculated which gave the percentages of each size, which should be present. The different sizes were weighed out according to the percentages so determined. The table shows the difference between the composition of the original and the "rectified" grog.

| Size. | Original. | Rectified. |
|---|---|---|
| Through 10 on 16 | 33.5 per cent | 24.2 per cent |
| Through 16 on 25 | 18.1 per cent | 14.0 per cent |
| Through 25 on 40 | 17.9 per cent | 16.5 per cent |
| Through 40 on 60 | 10.8 per cent | 10.2 per cent |
| Through 60 on 100 | 8.4 per cent | 10.3 per cent |
| Through 100 | 11.3 per cent | 24.8 per cent |

The following mixes were made up:

(1) Seven parts of good, dense burning, fireclay, with nine parts ordinary grog.

(2) Seven parts of the same clay, with nine parts of rectified grog.

(3) Six parts same clay, with nine parts ordinary grog.

(4) Six parts same clay and nine parts rectified grog.

All these mixes were worked as nearly as possible in the same way and for the same time, pressed into molds, dried and burnt at 1000° C. for 24 hours.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Pounds per square inch | 270 | 341 | 233 | 301 |

After burning for 48 hours at 1100-1200° C. we had

| | | |
|---|---|---|
| Pounds per square inch | 284 | 376 |

This amounts to a gain in strength of nearly one-third. Such close sizing is, of course, not feasible outside the laboratory, but valuable results can be obtained by much rougher sizing, well within commercial possibilities, as shown by the following experiment:

A grog was used giving the following mechanical analysis:

| Through 10 on 16 | 42 per cent. |
|---|---|
| " 16 " 25 | 22 " " |
| " 25 " 30 | 9 " " |
| " 30 " 50 | 12 " " |
| " 50 | 15 " " |

From this another grog was made up:

| Through 10 on 16 | 24 per cent. |
|---|---|
| " 16 " 30 | 26 " " |
| " 30 | 50 " " |

These two grogs were worked up with the same bond clay as in the previous experiment and burned at 1100° C. Seven parts of clay were used to nine of grog. The following figures were obtained:

| | Original grog. | Sized grog. |
|---|---|---|
| Shrinkage strain | 243 lb. | 371 lb. |
| Shrinkage | 4.84 per cent. | 5.44 per cent. |

The sized grog blocks shrank on burning more than the ordinaries, due, I think, to the fact that there was less internal cracking. Naturally, the densest mass would tend to have the smallest dimensions.

I have no opportunity of testing this out on a commercial scale, but I believe it would be worth while for some brickmaker to try it out. It must be borne in mind that the strength of these blocks made up with the original grog is high. Much of the firebrick, particularly the higher refractory stuff I have come across, is vastly lower than either. Some 2-in. bricks I have recently examined could be pulled in two with the hands.

Where a high refractory coefficient is obtained by cutting

down the bond clay to a minimum it seems to me that every-
thing that can be done to make that bond clay do every pound
per square inch of bonding possible should be done.

And even where the clay is of the same refractory coefficient
as the grog, the increased density and strength of the ware
would probably repay the trouble for many purposes.

*New Jersey Zinc Company.*

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## Concentration of Fine Sand on a Belt Vanner*

### By T. M. Owen and J. F. Stephen.

The Junction North concentration mill at Broken Hill,
N. S. W., uses side-discharge belt vanners to concentrate the
galena remaining in fine table-tailing. The vanner belt is sup-
ported on $3\frac{1}{2}$ in. rollers spaced at 12 in. centers along the frame.
The belt offers a dressing surface of 10 ft. 6 in. by 3 ft. 8 in.,
or about 38.5 sq. ft. The belt is made of two-ply, 32-oz. duck,
with a coating of rubber on each side. The machine is given
$245\frac{3}{4}$ in. strokes per minute and the belt travels at the rate of
15 ft. per minute. The dressing surface has a rise of $\frac{5}{8}$ in. in
its length, and a fall of 3 in. across its width. The machine
makes but three products, which are discharged at the side of
the belt, the concentrate being washed off by a strong water
spray.

The feed supplied to these machines has rather peculiar prop-
erties. It first comes into the mill as a primary product from
the rolls, being the undersize from a $\frac{1}{2}$ in. by $\frac{3}{4}$ mm slotted
screen; it then passes over Krupp tables, which take out a lead
concentrate, sending the whole of the remaining pulp to Callow
screens. These screens are fitted with a 40-mesh brass wire
cloth, aperture 0.4216 mm or 0.0166 in. The undersize from
these Callow screens constituted the feed of the vanners under
consideration. The feed consists essentially of a mixture of
quartz, rhodonite, garnet sandstone, galena and blende, the
greater portion of the gangue being quartz and sandstone in
varying proportions. Coming almost direct from the first
crushing, the feed is very sensitive to any changes in the physical
properties and grade of the crude ore; at one time the predomi-
nant gangue may be quartz, and a little later consist almost
entirely of garnet sandstone. Thus the machine has to separate
a lead concentrate from a gangue of two distinct types, light
and heavy. Inasmuch as the types are present in varying and
continually changing proportions, the separation may be re-
garded as one difficult to effect efficiently.

The results of the test given herewith represent the work
of one vanner operating under typical conditions for one hour.

*Concentrate.*—Dry weight, 240 lb., or 14.2 per cent; bulk
assay, 71.4 per cent lead.

| Sieve. | Per cent weight each grade | Assay lead per cent. | Per cent lead to total lead. |
|---|---|---|---|
| On 40 mesh ... | 0.20 | 64.8 | 0.18 |
| " 60 " ... | 8.70 | 79.6 | 9.61 |
| " 100 " ... | 6.17 | 80.6 | 6.90 |
| " 120 " ... | 14.17 | 79.8 | 15.68 |
| —120 " ... | 70.76 | 68.9 | 67.63 |

*Middling.*—Dry weight, 600 lb., or 35.7 per cent; bulk assay,
8.8 per cent lead.

| Sieve. | Per cent weight each grade | Assay lead per cent. | Per cent lead to total lead. |
|---|---|---|---|
| On 40 mesh ... | 1.00 | 34.7 | 4.19 |
| " 60 " ... | 13.34 | 16.2 | 25.66 |
| " 100 " ... | 4.03 | 7.2 | 3.46 |
| " 120 " ... | 12.88 | 4.1 | 6.26 |
| —120 " ... | 68.75 | 7.4 | 60.43 |

*Tailing.*—Dry weight, 842 lb., or 50.1 per cent; bulk assay,
4.4 per cent lead.

| Sieve. | Per cent weight each grade | Assay lead per cent. | Per cent lead to total lead. |
|---|---|---|---|
| On 40 mesh ... | 8.91 | 2.6 | 5.53 |
| " 60 " ... | 29.74 | 2.2 | 15.55 |
| " 100 " ... | 16.01 | 2.0 | 7.60 |
| " 120 " ... | 11.96 | 1.6 | 4.57 |
| —120 " ... | 33.38 | 8.4 | 66.75 |

From the foregoing figures a feed sample is built up, giving
the following:

*Feed.*—Dry weight, 1682 lb. Average assay, 15.34 per cent
lead.

| Sieve. | Per cent weight each grade | Assay lead per cent. | Per cent lead to total lead. |
|---|---|---|---|
| On 40 mesh ... | 4.849 | 5.4 | 1.70 |
| " 60 " ... | 20.897 | 10.0 | 13.58 |
| " 100 " ... | 10.336 | 9.4 | 6.31 |
| " 120 " ... | 12.604 | 15.0 | 12.31 |
| —120 " ... | 51.314 | 19.7 | 66.10 |

For purposes of comparison a sizing on a bulk sample of
vanner feed is appended. This sample was taken at the close
of the above test, and a close similarity will be noted between
this bulk feed sample and the built-up feed sample given above.

*Vanner Feed.*—Bulk assay, 14.6 per cent lead.

| Sieve. | Per cent weight each grade | Assay lead per cent. | Per cent lead to total lead. |
|---|---|---|---|
| On 40 mesh ... | 5.3 | 8.8 | 3.2 |
| " 60 " ... | 21.7 | 10.2 | 14.8 |
| " 100 " ... | 6.8 | 9.0 | 4.1 |
| " 120 " ... | 15.6 | 10.7 | 11.2 |
| —120 " ... | 50.6 | 19.7 | 66.7 |

*Concentrate.*—Figuring from the bulk assays of the products,
the extraction of lead appears to be 65.5 per cent in the form of
a 71.4 per cent lead concentrate; from the various sizing samples
comes out rather higher —66.71 per cent as a 72.1 per cent lead
concentrate. The extraction of lead from the —60 + 120-mesh
material is very high, being about 78 per cent; from the — 120-
mesh material the extraction is slightly lower, 68 per cent; and
from the +60-mesh material the extraction is extremely low,
being but 47 per cent on 60 mesh and 7 per cent on 40 mesh.

For an explanation of this large variation of extraction be-
tween the fine and coarse sizes it is necessary not only to refer
back to the sizing tests, but to consider what happens to the
material when it is fed to the vanners. An examination of the
feed dissection shows that there is a gradual increase in values
as the particles increase in size, due, no doubt, to the difference
in crushing resistance between the gangue and the mineral.
As extraction depends largely upon the grade of material
treated, it is natural to expect the higher extraction from the
finer size. In the foregoing test this is shown to be true up to a
certain point, and it is here that it becomes necessary to con-
sider the effect of the machine.

The efficient concentration of galena from gangue on a ma-
chine of this type depends largely upon the property of adhesion
which this mineral seems to possess. Size of particle and
specific gravity are other properties which affect the separation.
The dressing belt is a plane surface, and can only be expected
to deal with such material as will settle on it. When a pulp is
fed onto this surface the heavier particles naturally settle first.
The lighter particles travel farther on and do not settle until
the water current has retarded. If the current is running right
across the belt, particles of a certain size and weight—depending
on the strength of the current—do not have a chance to settle
at all, and go into the tailing without any treatment whatever.
The drop in extraction on the — 120 mesh material is due to the
loss of such particles. Had sieves finer than 120 mesh been
available the effect of this loss of finer particles would have
been more striking.

As the settled material travels along with the belt it is sub-
jected to the cross flow of the dressing water, and the gangue,
possessing but little "cling," is washed off more easily than the

mineral. The lead gradually becomes less as the belt travels forward and the galena particles become more exposed to the direct action of the water. When these particles come under the strong flow of the concentrate spray, some of the larger sizes are washed and become associated with gangue material, finally going to the middling. The escape of these particles to the middling, combined with the low assay of the coarse sizes of the feed, accounts for the low extraction of coarse lead shown in the vanner concentrate.

*Middling.*—The proportion of this product is at once noted as being high; the explanation of this lies in the fact that the machine was not set up for experimental purposes. To cope efficiently with the changing character of the feed it was necessary to safeguard the grade of the tailing by cutting off a large proportion of middling. With a very uniform feed the amount of this product could be greatly reduced without materially affecting the grade of tailing. On some of the experiments the middling was reduced to 15 per cent of the total weight of feed, and then assayed but 9.7 per cent lead. It is considered that, with a steady rate of feed, these results could be obtained regularly.

An examination of the sizing table of the middling shows that the high lead values are contained in the coarser sizes—the 40 mesh assaying 34.7, and the 60 mesh assaying 16.2 per cent lead, while the bulk assay is 8.4 per cent lead. An inspection of the dried sample shows it to contain large particles of free lead. These particles are forced into the middling by the concentrate spray, as explained above. The low assay value of the —120-mesh size—7.4 per cent lead—goes to prove that the strong flow of water from this spray forces but a small quantity of fine lead into this product.

An efficient separation of the free lead contained in the middling can be effected by mixing the product with the vanner feed and returning it to the machines. The same proportion of coarse lead again goes to the middling, while the surplus is forced into the concentrate as a clean product. As there is almost enough feed of the class already described to supply the seven vanners available, but a small quantity of the vanner middling is returned to the machines—only sufficient to keep a fairly constant rate of feed. The remainder is mixed with the Wilfley feed, which is a coarser product, and contains very little sandstone.

*Tailing.*—An examination of the sizing table of the tailing shows that the —120-mesh product assays 8.4 per cent lead, and contains 66.7 per cent of the total lead held in this product. The 120-mesh material assays but 2.1 per cent lead. It has already been stated that when the feed pulp comes onto the machine, particles of a certain size and weight, depending on the strength of the water current, do not have a chance to grip the belt, but go directly to the tailing compartment. Such particles are found in the material which passes the 120-mesh sieve, and are unsuitable for treatment on a sand vanner. It is commercially unprofitable to separate such particles by screening, but a partial separation can be effected by delivering the feed to the machine with as little water as possible. Particular attention has been paid to this point, and the average consistency of the feed pulp is one part of solids to 1.65 parts of water by weight.

A washing test of the —120-mesh material contained in the tailing showed that 46.5 per cent of the total lead contained in the tailing is present as a very fine slime, and can be easily removed. A separation on this principle is effected in the bulk tailing from the sand vanners by running them to a small settler which discharges thickened sand at the bottom, and slime and water at the top. This slime is settled and returned to slime vanners for retreatment.

Summing up the results of the above test it was found that the machine handled material at the rate of ¼ ton per hour; that in one operation, despite the presence of large quantities of heavy garnet sandstone gangue, 14.2 per cent by weight of this material was discharged as a high-grade lead concentrate containing 65.5 per cent of the total lead value; that 35.7 per cent by weight of the material handled was turned out as a middling product, containing free lead in a form eminently suitable for subsequent recovery; that 5.25 per cent by weight of the material handled was present as slime in the tailing and could be separated in a form suitable for retreatment; that 44.85 per cent by weight of the material handled was discharged as a finished product suitable for dumping, containing but 7.33 per cent of the total lead value and too low grade for retreatment.

The largely varying amounts of garnet sandstone in the feed make very little difference in the working of the vanner, but, in the presence of any quantity of garnet sandstone, the Wilfley table fails to separate a clean concentrate. To further explain this point the results of two typical tests are given: A No. 5 Wilfley table was fed with material of the same type as that treated by the vanners. Following are the results:

*Test No. 1.*—Gangue containing a very small percentage of garnet sandstone—

| | | | |
|---|---|---|---|
| Concentrate | 72.2 per cent lead. | | |
| Middling | 12.5 " | " | " |
| Tailing | 4.1 " | " | " |
| Slime | 17.2 " | " | " |
| Extraction | 61.2 " | " | " |

This shows good work, but not quite as good as that of the vanner.

*Test No. 2.*—Gangue containing a large percentage of garnet sandstone—

| | | | |
|---|---|---|---|
| Concentrate | 61.8 per cent lead. | | |
| Middling | 25.0 " | " | " |
| Tailing | 3.3 " | " | " |
| Slime | 20.4 " | " | " |
| Extraction | 51.4 " | " | " |

These figures show a low-grade concentrate with a high-grade middling, combined with a rather poor extraction of the lead values. When the table is working it is at once apparent that it fails to give a good separation; the sandstone rides on top of the galena, and the division between concentrate and middling is poorly marked. Below the point where the concentrate is cut off an intimate mixture of sandstone and galena, assaying from 40 to 50 per cent lead, extends for about 5 in. This material is too low grade for concentrate, and had to be run into the middling, explaining their high grade. The extraction is very poor compared with that of the vanner.

The authors conclude that in the treatment of fine, heavy garnet sandstone sand the belt vanner is a more efficient machine than the Wilfley table. The proportion of middling returned for retreatment is 15 to 20 per cent of the total feed; the proportion of finished products (tailing and concentrate) is 80 to 75 per cent of the total feed, and the remaining portion of 5 per cent is slime which is available for retreatment or stacking.

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**Fixation of Atmospheric Nitrogen in France.**—It is reported from France that the company "La Nitrogène" has just started a plant at Roche de Rame, Hautes-Alpes, for the production of nitric acid from atmospheric air by means of arc discharges. They are using the Pauling process, operating under license from the Salpetersäure-Industrie-Gesellschaft in Gelsenkirchen. The Pauling process was described and illustrated in our vol. VII, p. 430, the first plant using this process being located at Innsbruck. In the new French plant water power is also used; the hydro-electric installation comprises four units of 2000 hp each. The furnaces are arranged in two rows in a separate building. Each furnace has two arcs in series. Three-phase currents at 4000 volts with a frequency of 50 periods are employed. The phases are divided equally between three furnaces. At present the capacity of each furnace is 500 hp, but this will probably be raised to 1000 hp. In normal operation the yield of nitric acid is stated to be 60 to 70 grams per kw-hour. The whole plant is almost automatic, so that little hand labor is required.

## Cupro-Nickel Steel.[1]

### By G. H. Clamer.

The iron-nickel and iron-copper series of alloys are of particular interest as showing what surprising results are obtained by the joint addition of copper and nickel. For example, alloys can be produced carrying from 5 per cent to 20 per cent of copper, which without nickel would be extremely hard, brittle and red short, but these become, by the addition of nickel in the proportion of from 20 per cent to 50 per cent, highly ductile, easily forgeable and easily machinable. Such alloys are capable of being rolled into sheets or rods and can be machined without difficulty—in fact, they are quite soft.

The following are tests of two typical alloys within these ranges of proportions:

|  | No. 1. | No. 2. |
| --- | --- | --- |
| Copper, per cent | 9.00 | 19.50 |
| Nickel, per cent | 22.00 | 45.00 |
| Carbon, per cent | 0.22 | 0.20 |
| Ultimate strength, pounds per square inch | 101,000 | 98,230 |
| Elastic limit, pounds per square inch | 57,300 | 54,150 |
| Elongation, per cent | 42.5 | 35.0 |
| Reduction of area, per cent | 61.5 | 47.9 |

These tests were made on rolled rods. The elastic limit, it will be noted, is quite low in proportion to the ultimate strength, which naturally accounts for their softness. Alloys at the lower end of the series can be bent cold to an angle of 180° without fracture, whereas those at the higher end cannot be bent so far. Alloys at the lower end of the series will resist corrosion in a highly satisfactory manner, and those at the upper end are practically non-rusting. Samples which have been exposed for the past year in contact with concentrated foundry gases, and at Atlantic City in contact with salt atmosphere, have demonstrated these facts. In addition to this, the alloys have a very low coefficient of expansion.

Just what uses such alloys might be put to has not yet been determined, but no doubt quite a number will suggest themselves, e.g., as a substitute for the present 25 per cent to 35 per cent nickel-steels and probably for quite a number of others. For the cupro-nickel steel can be produced at a very much lower cost, not only because of the substitution of copper for nickel (copper selling at the present time at less than one-third the price of nickel), but because the alloy can be made from monel metal, a commercial alloy of copper and nickel, containing copper and nickel in the correct proportions for making such a steel. Monel metal sells for about the price of copper.

It is also possible to make the steel directly from Sudbury nickel ores, by simply smelting and bessemerizing them to eliminate the iron to the extent desired, roasting the matte produced, and finally reducing the combined oxides resulting from roasting the matte. Either by the use of monel metal for making the steel alloy, or by the direct production of it from the ore, it is thought that the cost of production might be sufficiently reduced to make it attractive for roofing, gutters, spouts, ventilators, and for many other uses where its resistance to corrosion and its low coefficient of expansion will warrant the cost.

Sheets of cupro-nickel steel can be produced to sell at a very much lower price than copper sheets and probably for two to four times the price of commercial coated iron and steel sheets; but since the alloy is about twice as strong as the soft steel and three times as strong as copper sheets, thinner gages can be used. The alloys at the higher end of the series are non-rusting.

Steels within this range of proportions of copper and nickel have a crystalline structure, such as is possessed by nickel steels carrying above approximately 25 per cent of nickel, or with a somewhat lower percentage of nickel if carbon is present in an appreciable amount—in other words, like nickel steel within the crystalline range—the copper apparently acting very much like nickel. It will be noted that the physical properties are very similar to those of the same nickel steels without copper.

Noting the curious and unexpected results obtained with these high copper-nickel alloys, I became curious to know what would be the effect of replacing part of the nickel in nickel steel within the pearlitic range of copper, and accordingly made such steels with from 1 per cent to 8 per cent of monel metal, in which the proportion of nickel to copper is, roughly, 2.5 per cent of nickel to 1 per cent of copper. Here again the copper really acts like so much nickel, at least when present in these relative proportions, and it is possible, therefore, to produce a steel of practically the same physical properties as nickel steel at very much reduced cost. In these steels the nickel, iron and copper are in the same relative proportions in which they exist in some of the prominent mines at Sudbury, where vast deposits exist, average analysis of these ores being as follows:

| Copper | 0.8 to 2 per cent. |
| --- | --- |
| Nickel | 2 to 5 per cent. |
| Iron | 35 to 52 per cent. |
| Sulphur } Gangue } | Remainder. |

It will be seen that, by the operation of reducing this ore to matte, calcining the metal to remove the sulphur, and reducing the calcined product, this steel can be produced almost to any desired formula.

The valuable properties of the nickel steels—i.e., steels carrying below 6 per cent of nickel—have, of course, long been recognized, and recently the value of copper as a valuable constituent of steel, instead of a metal to be looked upon as a detrimental impurity, has also become recognized. It is probably not quite so surprising, therefore, that the joint addition of copper and nickel within the range of proportions here considered is productive of valuable results. The addition of these two metals in combination seems to have the same effect upon the steel as if they were individually added, the copper in its effect really being about the same as so much added nickel. It is possible, therefore, to replace part of the nickel in nickel steel by copper without materially altering its physical properties. The following table gives the physical properties of some of these alloys:

| No. | Monel metal, per cent | Carbon, per cent, | Ultimate strength lbs, per sq. in. | Elastic limit, lbs. per sq. in. | Elongation, per cent. | Reduction of area per cent. |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 4 | 0.11 | 83,600 | 66,300 | 26.5 | 65.4 |
| 2 | 3 | 0.10 | 75,300 | 64,600 | 25.5 | 71.4 |
| 3 | 2 | 0.15 | 75,500 | 63,700 | 28.0 | 65.4 |
| 4 | 4 | 0.67 | 151,000 | 120,000 | 8.0 | 15.8 |

Recently Messrs. Burgess and Aston, working quite independently of me, have confirmed these results with alloys which they have made with electrolytic iron, which has been quite gratifying.

Although I have not had an opportunity to study all the properties of some of the alloys within these ranges, i.e., the pearlitic and crystalline alloys, nevertheless, it would seem from the tests so far made, that these alloys may become of commercial value, especially as we now have at hand a commercial monel metal—and the further possibility of producing them directly from Sudbury ores.

\* \* \*

In the discussion which followed, Dr. John A. Mathews, of the Halcomb Steel Company, of Syracuse, N. Y., said that the general trend of scientific work in connection with the influence of copper on steel has been to show that, in any ordinary quantities in which it is likely to be found, its effect is not marked one way or the other, or may even be beneficial.

Dr. Mathews then gave some data on a particular experiment with cupro-nickel steel which is of more than ordinary interest, owing to the fact that the heat of nickel steel containing

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[1] Extracts from a paper read at the recent Atlantic City meeting of the American Society for Testing Materials. The author begins with a review of recent work on the properties and constitution of alloys, with special reference to iron-nickel and iron-copper alloys and to the investigations of C. F. Burgess and J. Aston on this subject. The present paper is of special interest in connection with the article of Burgess and Aston in our last issue (page 452) on the strength of alloys of electrolytic iron with monel metal.

copper was melted in their Héroult electric furnace, and that the pig iron used in this heat was produced in Canada in the Héroult smelting furnace which was installed there some years ago; that is, the entire heating from the ore to the finished product was by means of electricity. This is probably the first heat of steel so made in the United States.

The pig iron as produced from certain of the Canadian ores carries a considerable amount of nickel and copper, and it was with a view to seeing what results could be obtained from this pig iron that they made a cold heat, charging cold pig and ore into their furnace. This heat gave steel of the following analysis:

| | | | |
|---|---|---|---|
| Carbon | 0.44 | per cent | |
| Silicon | 0.034 | " | " |
| Manganese | 0.50 | " | " |
| Phosphorus | 0.013 | " | " |
| Sulphur | 0.013 | " | " |
| Nickel | 3.62 | " | " |
| Copper | 0.48 | " | " |

It must be remembered that all the nickel and copper present were contained in the original pig iron used. They had no definite analysis in mind when they started this heat, but were more interested in finding what grade of steel would result from the grade of pig used. The ingots were clean and worked very satisfactorily under the hammer, and the 0.48 per cent of copper present seems to have exerted no deleterious influence as regards the heating or working.

For the sake of comparing this steel with another steel of approximately the same analysis, they selected an open-hearth nickel steel which analyzed as follows:

| | | | |
|---|---|---|---|
| Carbon | 0.46 | per cent | |
| Silicon | 0.066 | " | " |
| Manganese | 0.70 | " | " |
| Phosphorus | 0.021 | " | " |
| Sulphur | 0.034 | " | " |
| Nickel | 3.36 | " | " |

An examination of this heat showed that it also contained about 0.10 per cent of copper.

The physical tests to be mentioned later were made from round bars, ⅞ in. in diameter, and the greatest care was used in their heat treatment. Tests were made in duplicate, and the annealing of the bars from the two heats was done at the same time, so as to avoid any possible difference in the annealing temperature. It was noted that the open-hearth steel machined a little more freely than the electric-furnace steel containing 0.48 per cent of copper, but here the superiority ended. The tensile tests of the material as rolled gave the following values:

| | O. H. Nickel. | Cupro-Nickel. |
|---|---|---|
| Elastic limit, lbs. per sq. in. | 74,625 | 72,400 |
| Tensile strength, lbs. per sq. in. | 122,000 | 115,000 |
| Elongation in 2 in., per cent. | 16 | 22 |
| Reduction in area, per cent. | 34 | 51 |

In the annealed condition the physical tests were as follows:

| | O. H. Nickel. | Cupro-Nickel. |
|---|---|---|
| Elastic limit, lbs. per sq. in. | 64,750 | 63,750 |
| Tensile strength, lbs. per sq. in. | 119,000 | 107,300 |
| Elongation in 2 in., per cent. | 17 | 25 |
| Reduction in area, per cent. | 37.5 | 48 |

Samples of both steels were heated to 1500° Fahr., quenched in oil, and drawn back to a temperature of 800° Fahr. and maintained at that temperature for 20 minutes. In this condition the results of physical tests were as follows:

| | O. H. Nickel. | Cupro-Nickel. |
|---|---|---|
| Elastic limit, lbs. per sq. in. | 154,500 | 154,000 |
| Tensile strength, lbs. per sq. in. | 175,000 | 172,500 |
| Elongation in 2 in., per cent. | 9.75 | 13.25 |
| Reduction in area, per cent. | 30.8 | 49.1 |

In all of the above tests, the elastic limits and tensile strengths are not very different for the two steels, but the great superiority of the cupro-nickel steel in elongation and reduction of area is most noticeable. The presence of the copper certainly has not in any way decreased the toughness of the steel, as manifested in its percentage of elongation and reduction of area, but the most remarkable difference in the two steels was noticed in samples which had been quenched as before at 1500° Fahr. and drawn back to 600° Fahr. In this condition, both steels showed an elastic limit of about 185,000 lb. per square inch, and a tensile strength slightly above 200,000 lb. per square inch; but, while the open-hearth steel was decidedly brittle after this treatment, giving only 2 per cent elongation and 4 per cent reduction in area, the electric-furnace product gave 12 per cent elongation and 46 per cent reduction in area.

So far as this single test is concerned, therefore, there is absolutely no evidence to show that the copper has exerted a harmful influence upon the nickel steel, and we must either ascribe its superiority to the presence of copper, or to the superiority of the electric method of melting, or to both acting jointly. From an extended experience with the electric-furnace product as compared with the open-hearth nickel steels in carbons varying from 0.10 up to 0.50 per cent, there no longer remains any doubt in Dr. Mathews' mind as to the superiority of the former over the latter.

## Recent Advances in Electric Pyrometry.

An interesting review of progress in pyrometry was given in a recent paper by Mr. Robert S. Whipple before the Birmingham Metallurgical Society. The paper, which is printed in full in the London *Engineering* of July 22, discusses in succession the advances made in gas thermometry, resistance thermometry, thermo-electric pyrometry, and radiation pyrometry.

We give here in abstract those parts of Mr. Whipple's paper which deal with electric resistance and thermo-electric pyrometry.

**Resistance Thermometry.**—There is not, according to Mr. Whipple, any striking advance to report in this branch of thermometry. A valuable paper by Dr. Harker on "High-Temperature Standards of the National Physical Laboratory" (*Philos. Transact.*, Royal Society, A, Vol. 203, pages 343 to 384), gives the results of a series of comparisons made between the resistance and thermo-junction standards and the nitrogen-gas thermometer up to 1000° C. These results entirely justify the use of Callendar's parabolic formula up to 1000° C.

Waidner and Burgess (*Bull. Bur. of Standards*, Vol. 6, No. 2) have since confirmed Harker's results in an investigation of the behavior of resistance thermometers made of platinum wires of varying degrees of purity. The following is a brief summary of their results, but those interested should refer to the original memoir:

1. Temperatures defined by the resistance thermometers of pure platinum calibrated by Callendar's formula at 0° C. and 444.70° C., the boiling point of sulphur, agree with temperatures on the accepted gas scale from 0° C. to 1100° C.

2. Thermometers made of impure platinum and calibrated in the same way do not define the temperature scale as those of pure platinum, the divergence increasing with the impurities in the metal.

3. If the thermometers of impure platinum are calibrated at a fourth point, such as the melting point of silver, and the Callendar formula modified accordingly, then the scale is brought into close agreement with that of the thermometer of pure platinum.

4. For temperatures above 900° C. the constants of platinum thermometers undergo gradual changes, necessitating frequent recalibration in work of high precision. These changes are greatly reduced by annealing the thermometers for several hours at a temperature higher than that at which they are to be subsequently used.

5. In pure-wire thermometers these changes are extremely small, very much less than in the case of those made with impure wire. In the latter case the thermometers appear to in-

prove with time as though the impurities (such as iridium) evaporate by successive heatings.

In the construction of resistance thermometers some improvements have been introduced, the most important being that due to Dr. Haagn (report of Reichsanstalt, *Zeit. f. Instrumentenkunde*, 1907, No. 4, page 116), who suggested to Messrs Heraeus, of Hanau, the construction of a thermometer in quartz, the wire being wound on a rod of quartz and protected by a very thin tube of quartz fused over it. This thermometer can be made as small as 25 mm long and 3 mm in diameter, and yet be comparatively robust. By this arrangement the wire is protected from the injurious effect of gases and mechanical strain; it also very quickly attains the temperature of the surrounding medium. It is, however, handicapped with a drawback that quartz devitrifies if exposed for any length of time to temperatures as high as 1000° C.

Two new methods of winding the thermometer coils for avoiding strain on the wires are shown in the paper by Waidner and Burgess, previously referred to; one, in which, by means of a modified form of mica frame, a flexible mounting is given to the wire (Fig. 1), and the other, due to Northrup, in which stouter wires, in the form of a spiral without any support, are employed (Fig. 2).

**Thermo-Electric Pyrometry.**—Progress has here been made essentially in three directions, which will be discussed successively under *a*, *b* and *c*.

**(a) Increasing the Purity of the Metals Employed in the Platinum Thermocouple.**—Great steps have been made comparatively recently in the production of pure and homogeneous metals for standard thermocouples. The firms of Johnson, Matthey & Company, of London, and Heraeus, of Hanau, have sunk a considerable amount of capital in large ingots of pure platinum, platinum with 10 per cent rhodium, and platinum with 10 per cent iridium for this purpose. In the case of a sample supplied for thermocouples to the National Physical Laboratory by Johnson, Matthey & Company, the analysis of the platinum-rhodium alloy was as follows:

Platinum = 89.9
Rhodium = 8.98

both being directly determined and no trace of any other metal being discovered. (J. A. Harker, *Proc. Royal Soc.*, Vol. 76, A, page 243.) The ingots owned by Johnson, Matthey & Company have been found to be exceptionally homogeneous, wires obtained from any part of the ingot giving the same e.m.f.

Messrs. Heraeus have now been able to repeat their standard of purity for some time, as the following data supplied by them will show, giving the average e.m.f. at 1000° C. for the last six years:

Year.
1904 = 9.52 millivolts.
1905 = 9.53       "
1906 = 9.53       "
1907 = 9.57       "
1908 = 9.59       "
1909 = 9.55       "

As a result of the work of these two firms it is possible to obtain a second thermocouple similar to one previously obtained, which may be used without introducing any serious error on the same galvanometer or recorder.

It has been known for some time that platinum thermocouples deteriorate in an atmosphere of hydrogen, but it has not been possible to account for a large number of the failures. No very definite information was available on this subject until the paper published by White (*Phys. Review*, December, 1906). In this paper it was shown that the main source of error in thermoelements is non-homogeneity, by the removal of which, in most cases, far greater accuracy may be attained than has hitherto been realized. It was also shown that the iridium slowly sublimes from the platinum-iridium side of a couple and enters into combination with the platinum side, thus slowly reducing the e.m.f. given by the couple. This sublimation has

been found to commence at 900° and to become serious at 1200° C.

The destruction of the platinum, platinum-rhodium thermocouples in the earlier stages of Day's later work could only be accounted for by the sublimation of the platinum-iridium heating coil employed in the furnace. This was replaced by a platinum coil and finally platinum-rhodium was substituted for the gas thermometer bulb itself because the iridium from the platinum-iridium bulb tended to destroy the couples. (*Am. Jour. of Science*, Vol. 29, February, 1910.)

Iron has undoubtedly a disastrous effect on platinum, and the
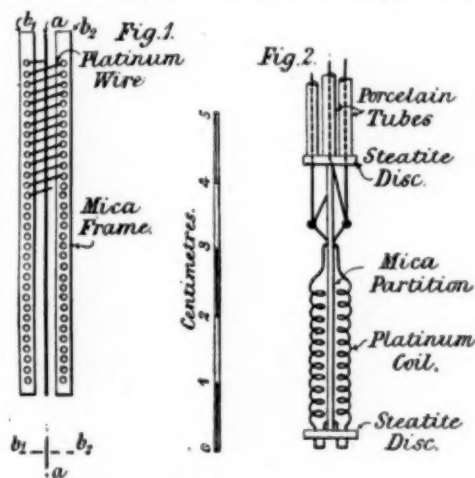


FIGS. 1 AND 2.—METHODS OF WINDING PYROMETER COILS.

destruction of large numbers of couples may be put down to this cause.

Annealing a low-reading thermocouple to a temperature of 1200° C. will frequently restore it to its original e.m.f.

When the use of contaminated elements is necessary, fair accuracy can still be obtained if the defective couples are frequently compared with standard ones.

**(b) Production of Cheaper, or Base Metal, Couples.**—A large number of wires have been suggested for making cheaper thermoelements. Onnes and Clay have employed gold and silver elements for very low temperatures with success, this couple showing itself at — 253° C., as read on a hydrogen thermometer, to be twice as sensitive as constantan steel. (*Konink. Akad. Witensch.*, Amsterdam *Proc.*, 11, page 344, December, 1908.)

The most satisfactory base-metal couple for temperatures not exceeding 700° C. is undoubtedly copper-constantan (constantan = 60 per cent copper, 40 per cent nickel), and this couple has been used in several scientific researches. (E. H. Rayner, *Jour.*, Inst. Elec. Eng., Vol. 34, page 628; A. Gamgee, *Phil. Transact.*, B, Vol. 200, pages 219 to 240.)

Among other couples may be mentioned:
Iron-constantan.
Iron-nickel.
Iron-nickel chromium.
Copper-nickel.

A useful book by Prof. H. Pecheux has lately been published on the thermocouple. ("Le Pyromètre Thermo-Electrique," Paris: Gauthier-Villars.) In this he urges the adoption of the copper-nickel couple for use up to temperatures of 900° C., and he also shows that although it is impossible to make one parabolic formula fit the whole range of usefulness of the couple, yet with the aid of three formulas covering varying parts of the range the observed results agree with the calculated results to within 1° over the greater part of the scale.

Mr. Whipple's own experience shows that it is extremely difficult to obtain homogeneous wires, and, therefore, for accurate results it is necessary to calibrate every individual couple, and even then the calibration may be found to have seriously

altered, if, by any chance, the couple has been overheated or, perhaps, overannealed.

For accurate work it is customary to maintain the cold junction of a thermocouple at 0° C. (By using a Dewar flask to hold the ice a small quantity can be made to last for a considerable time.) But not infrequently, in what may be called semi-scientific work, it is not easy to control the cold junction temperature. Although it has been customary to have the difference between the temperature of the head of the thermometer and 0° C. and to add this quantity to the obtained hot junction temperature provided the cold junction correction does not exceed 50° C., yet this is incorrect, as the relation of the e.m.f. to temperature is not a straight line. R. Vogel (*Zeit. f. Anorg. Chemie*, 1905, 45) appears to have been the first to have calculated and applied correction factors for this cold-junction temperature. The matter has since been fully discussed by C. Offerhaus and Ernst H. Fischer (*Electrochem. and Met. Ind.*, Vol. 6, page 362, September, 1908), who show that the correction depends on both the hot and cold junction temperature and the particular couple. Briefly, they show that the true temperature of the hot junction is not, starting with the needle at zero (the cold junction having the temperature of the room), the temperature which corresponds to the millivolt reading, but is found by adding the number of millivolts which corresponds to the temperature of the cold junction to the millivolt reading.

**(c) Methods of Measurements with Thermocouples.—** For accurate work the conditions imposed upon a potentiometer for use with thermo-electric couples are very exacting and may be grouped as follows:

1. If possible, temperatures up to 1600° C. must be read to 0.1° C. with a platinum, platinum-rhodium element; 0.1° C. corresponding to about 1/1000000 of a volt.

2. The potentiometer coils must be unaffected by leakage from external circuits. (This is important where, as is now generally the case, the thermocouple is being used in a furnace which is electrically heated by heating coils, the potential difference in which may be 100 volts or more, any leakage to the potentiometer coils introducing serious errors.)

3. Manipulation must be simple in order that quickly altering temperatures may be followed.

To meet the above condition various potentiometers have been designed. Several recorders of various types have been introduced for use with thermocouples. In connection with one of these some experiments have lately been tried with a view to increasing the stability of zero. It has been found that a phosphor-bronze wire reduces the creep from one-half to one-third that which would be given by the same wire rolled as a strip. The instrument is arranged to deflect across the scale for an e.m.f. of 1 millivolt. The total range of the recorder can be adjusted by means of resistances in series with the couple.

**Standardization.—** Mr. Whipple remarks that it is interesting to note the tendency of recent workers to adopt the melting points of pure metals as the standards of reference, several of the melting points being known to a high degree of accuracy. Unfortunately the metals cannot be obtained commercially sufficiently pure to guarantee an accuracy of 1° C. at the higher temperatures, but if an accuracy of 1° to 3° is sufficient, then Kahlbaum's best materials will answer the requirements.

It is hoped that in the near future the (British) National Physical Laboratory or some similar institution will be able to supply small quantities of pure metals, the melting points of which have been carefully studied.

The following are given by Mr. Whipple as the most satisfactory standardization points, the values given being as far as possible the latest determinations:*

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* Compare also the figures given by Dr. A. L. Day in the May issue of this journal, p. 260.—Editor.

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| Freezing point of | | | | |
|---|---|---|---|---|
| Freezing point of | tin | 231.92 | |
| " | " | cadmium | 321.01 | |
| " | " | lead | 327.42 | *Bulletin* of the Bureau of Standards, Vol. VI, No. 2. |
| " | " | zinc | 419.37 | |
| " | " | antimony | 630.7 | |
| " | " | silver | 960.88 | |
| " | " | copper | 1083.0 | |
| " | " | nickel | 1452.2 ± 2 | A. L. Day and B. B. Sosman, *Am. Jour. of Science*, Vol. XXIX, Feb., 1910. |
| " | " | cobalt | 1489.2 ± 2 | |
| " | " | palladium | 1549.2 ± 2 | |
| " | " | platinum | 1755.0 ± 5 | |

Boiling point of sulphur, 444.70°.

Black-body temperature of the crater of the electric arc, 3700° C. (This latter point is constant, even although the current through the arc is varied between large limits.)

\* \* \*

**The Thermo-Element as a Precision Thermometer.—** An interesting investigation of the use of the thermo-element as a precision thermometer has been carried out at the Geophysical Laboratory of the Carnegie Institution of Washington, the results being given in a paper by WALTER P. WHITE in the *Physical Review* of August. The investigation dealt with the construction, accuracy and convenience of the copper-constantan thermo-element. The data were derived from the study of four multiple thermo-elements which have been used for about three years as calorimetric thermometers at the Geophysical Laboratory, and also from a calibration where two of them were used side by side with a resistance thermometer to measure the same temperatures.

Constantan and copper were chosen as forming, on the whole, the best available combination for work at ordinary temperatures. Constantan and steel, its only serious rival at present, excels only in a slightly higher e.m.f. and has the disadvantages that (1) steel wire is not so readily obtainable insulated as the others, and (2) with constantan and steel we have two metals instead of one which may cause appreciable error from inhomogeneity—a defect which for most purposes evidently more than offsets the slight advantage in e.m.f.

The results are summed up as follows: The e.m.f. of a thermoelement, whether homogeneous or not, can be expressed as equal to $\int HdT$, where $H$ = thermoelectric power and $T$ temperature. It follows that the effect of each portion of a thermoelement is proportional to the magnitude of the temperature gradient in which it lies; hence the vital parts of a thermoelement are the parts along which the temperature varies; they mainly determine the calibration and the constancy; with them alone need the maker or user of the thermoelement be much concerned. In changing them (as by varying the depth of immersion in a furnace) the thermoelement itself is changed, if not homogeneous, while alterations in regions of uniform temperature distribution, as at the junction, have little effect on the temperature measurement.

Commercial constantan wire good enough to make thermoelements accurate to about 0.05 per cent is easily obtained and costs but little trouble in the selection, but cannot be relied upon without any test for possible inhomogeneity. Compensated thermoelements of higher accuracy, reading consistently to 0.0001°, for use at ordinary and low temperatures, can be made in a day or two each. Improvement in the accessory apparatus has shown that their constancy is about ten times that shown three years ago.

The accuracy of 0.0001° reached by the thermoelement can also be attained in its auxiliary apparatus (potentiometer, etc.). The resulting accuracy, both absolute and relative, and the sensitiveness are quite comparable with those of the best resistance thermometers yet used.

For the measurement of single temperatures the resistance thermometer is often more convenient. On account principally of the comprehensiveness of the potentiometer and its indifference to external contact resistances, the thermoelement is usu-

ally preferable where several different measurements are to be made at once. The thermoelement is also usually superior for differential measurements, and its advantages in this respect can be made available for calorimetric work by the substitution of a suitable comparison body for the usual ice bath.

A very convenient wire tester, a simple bath for testing and comparing thermoelements, and a convenient form of tabulation for calibration curves are also described in the paper.

\* \* \*

In connection with this investigation a paper by W. P. WHITE, H. C. DICKINSON and E. F. MUELLER should be mentioned, which is also published in the August issue of the *Physical Review*, on the calibration of copper-constantan thermoelements. A pair of copper-constantan thermoelements for use in calorimetric work was calibrated by comparison with resistance thermometers to an accuracy of 0.004°. It seems probable that the accuracy of the calibration could be considerably exceeded. A cubic equation probably represents the relation between temperature and e.m.f. in the interval 0° to 100° with an accuracy of 0.005° or better. New thermoelements may be very conveniently calibrated by direct differential comparison with those whose calibration is already known.

## The Constitution of Cast Irons and Carbon Steels from the Practical Standpoint.[1]

### BY DONALD M. LEVY.

The object of this paper is to offer a simplified view of the relations existing between iron and carbon over practically the whole range of cast irons and carbon steels.

It is especially desired to indicate how such a point of view helps toward a clear understanding as to the manner in which each particular constituent, such as the sulphur, the silicon, and the manganese, either singly or in conjunction, affects these relations in cast irons. It will thus, it is hoped, help toward an understanding of the direct relations which exist between the heat treatment, composition, and properties of these alloys. It may further, perhaps, indicate the value of very much of the scientific work which has too often been regarded as mainly of academic interest, but has, nevertheless, assisted toward a clearer understanding of the causes of many phenomena with which the practical man is greatly concerned.

For reasons which are discussed in an appendix the present equilibrium diagram cannot be regarded as altogether satisfactory as a full realization of the relations of iron and carbon in these alloys. It has tended to make the question so much a matter of the physical relations between these elements that the chemical side of the problem has not been sufficiently appreciated. It is hoped in this paper to indicate the primary importance of the meta-stable chemical compound iron-carbide, in connection with the constitution of iron and steel, and by noting the influence of the varying physical and chemical conditions upon it, to show how a clearer, simpler and more practical view is arrived at.

The object of this paper is therefore to classify cast irons and carbon steels as primarily a series of iron and iron-carbide alloys, and by means of what may be termed a constitutional diagram, to indicate what constituents tend to separate and the conditions under which these constituents separate in the alloys.

It is intended to show how (instead of the two systems hitherto considered necessary) the conception of a single series of alloys meets both the theoretical and practical requirements of the subject; affording a clearer idea of the real points of practical interest, and assisting in their application with some certainty to practical problems.

## The Iron-Carbide Series of Alloys.

In a Carnegie Research Memoir,[2] in which it was endeavored to find an explanation for the effects of sulphur in cast iron, conclusions were arrived at regarding the condition in which the carbon separated in cast irons, which offered a rational explanation for many long observed but hitherto unexplained phenomena. The part played by sulphur will be referred to later, but the observations concerning carbon may be quoted as follows:—

"The iron-carbon alloys can best be regarded as an iron: iron-carbide system, and when molten as solutions of iron-carbide in iron. The graphitic system is largely a secondary one, arising from decomposition of members of the first; graphite not separating as such from solution in iron, but occurring through the decomposition of previously separated or separating carbide (neither is the direct separation from solution of a graphite eutectic near 1130° C. probable). Carbon dissolves in iron as carbide, and separates from solution as such."

Goerens[3] has shown this to be so in an exhaustive and most admirable research.

There are many reasons which lead to this conclusion. In general, when a molten metal has placed in contact with it a non-metal, there is a tendency to combination between the two, and it is the compound which passes into solution in the metal. The case of iron illustrates this point very well. Melted iron exposed to air forms iron-oxide which is soluble in the liquid metal. Sulphur in contact with melted iron forms iron-sulphide, and this sulphide is dissolved; phosphorus forms the phosphide which dissolves; silicon forms the silicide, and the case of carbon is similar.

That is, carbon in contact with molten iron forms a carbide, and it is this carbide which, dissolving in the liquid iron, gives rise to cast irons and steels.

Conversely, on cooling, it is the carbide which first separates. Thus it will be seen that cast irons and carbon steel may well be regarded primarily as a series of alloys of iron and iron carbide, and that a constitutional diagram can be constructed to represent them.

This is shown in Fig. 1, and, to all intents and purposes, indicates what separations primarily occur in the course of solidifications and cooling; with the proviso always borne in mind, that such carbide is unstable, and tends to decompose to iron and graphite during and after separation.

If, as is surely always the case, one rarely thinks of carbide in cast irons without remembering the fact of its ready decomposition, such a diagram becomes at once capable of application intelligibly to the alloys of every-day practice.

It will be seen that this diagram corresponds in general tenor to the equilibrium diagram of iron-carbon alloys. This is but natural since separation of constituents is indicated in either; but the whole of the constitutional diagram of Fig. 1 has reference to the solubility of iron-carbide in iron, either solid or liquid, and indicates at what temperature it separates from solution. (See Appendix.)

The interpretation of this diagram is as follows:

Alloys in the molten state are to-day regarded as being largely analogous to ordinary liquid solutions, the more of a substance that is dissolved in the solvent the lower the freezing point of the solution becomes.

In the case of iron and carbon alloys, as the quantity of carbon increases, the melting or solidifying point becomes lower, so that, commencing with pure iron, which melts at 1505° C., as the quantity of carbon increases up to about 4.2 per cent carbon, the metal has a lower and lower melting point, until, with this 4.2 per cent carbon alloy, we have a melting point of about 1130° C. This is the alloy of the lowest melting point of the whole series, and it is known as the eutectic alloy. These facts are represented along line *AB* of Fig. 1.

As in the case of a cooling salt solution, it is excess water (ice) which crystallizes out first while the salt becomes stronger and stronger in the residual brine, so in the case of high iron-carbon alloys excess iron solidifies out of the solution first, most of the carbon as carbide remaining and gradually concentrating in the residual mother liquor.

But when the temperature has fallen to about 1130° C. this mother liquor also solidifies. It has remained liquid as long as it was able, but since this temperature (about 1130° C.) is the solidifying point of the most fusible alloy (the eutectic) of the series, it too becomes solid at this temperature.

On comparing the high iron-carbon alloys with a salt solution we have to notice an important distinction. In the latter case, pure ice tends to solidify first, while the salt remains dissolved in the brine, but in the former case the iron which first solidifies is not pure iron. Iron has the power of keeping
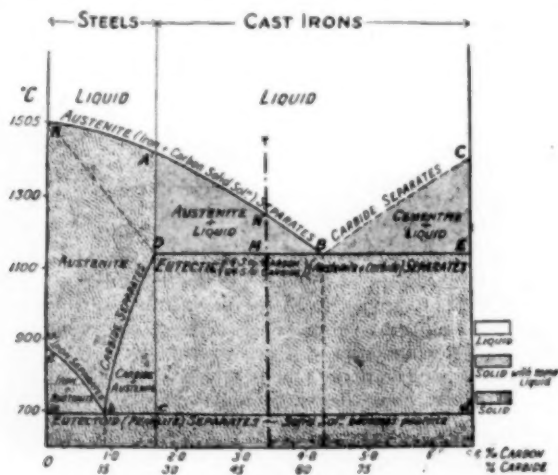


FIG. 1.—CONSTITUTIONAL DIAGRAM OF CAST IRONS AND STEELS.

some of the carbon dissolved in it, even when it is solid, to the extent of about 1.7 per cent carbon. Up to this percentage, therefore, the material solidifies as a homogeneous mass of crystals of iron containing the carbon in solid solutions, and no carbide is left behind to concentrate in a mother liquor, since it is all dissolved in the iron as it solidifies. To this solid solution the name "austenite" is given.

Its practical importance will be realized when it is seen (as may be observed from the diagram Fig. 1) that this range of alloys in which the carbon may be held wholly in solid solution constitutes steels. Beyond this proportion, where the solidifying iron cannot carry more than 1.7 per cent of carbon, some carbide has to remain in a mother liquid, and this separates later (along DE) as the eutectic of iron (that is, austenite) and residual carbide at about 1130° C. This range corresponds to the series of cast irons.

### Steels.

It has just been seen that the range of carbon steels comprises those alloys in which the iron has solidified, with the carbide dissolved in it in solid solution (AA', Fig. 1); that is, containing up to about 1.7 per cent of carbon.

If, now, this carbide can be retained dissolved in the solid steel a very hard material is obtained, and the hardening of carbon steels by quenching is simply the operation of cooling the metal so very quickly that the carbide does not get time or opportunity to separate from the solution as such, but remains dissolved in the solid metal. Quenching has to be carried out for reasons which can be understood on reference to the constitutional diagram (Fig. 13, and depends on the following data:

It is a fact well known, and practically universally recognized, that pure iron exists in a number of allotropic forms, each variety having certain properties which mark it as different from the others. It is beside the purpose of the present paper to discuss this matter in any great detail, but it will

suffice to say that for all practical purposes the form of iron known as gamma (γ) iron, which exists above the temperature corresponding to the arrest, Ar₃, has the power of dissolving carbon, and that the form known as alpha (α) iron, into which it eventually changes on cooling, does not possess this dissolving power. On cooling a carbon steel, therefore, a certain temperature is arrived at, at which there are present carbide of iron and a form of iron which are mutually insoluble.

Therefore, just as ice or salt must separate from a solution which can no longer dissolve it, so on cooling beyond a certain stage must this α-iron (known as ferrite) or this carbide (cementite) separate from the original solid solution (termed austenite).

This will be more readily followed perhaps by considering what occurs while a mild steel or a high-carbon steel cools down slowly. Attention may first be drawn to the very close analogy between the solid solution of carbon in γ-iron and an ordinary liquid solution (say, of salt in water), bearing in mind that just as salt is insoluble in solid water (ice) so is iron-carbide insoluble in α-iron (including for the present purpose β-iron under this variety). This is shown in Fig. 2. The parallelism is marked if it be remembered that

Iron-carbide is soluble in γ-iron.
Iron-carbide is *not* soluble in α-iron.
γ-iron changes to α-iron at 900° C.
The change point is lowered down to 690° C. by iron-carbide.
Salt is soluble in water.
Salt is *not* soluble in ice.
Water changes to ice at 0° C.
The change point is lowered down to — 23° C. by salt. (Fig. 2.)

*Mild Steel* (say, 0.24 per cent carbon).—This solidifies at 1492° C. to 1448° C.[a] as a homogeneous mass of crystals—austenite—iron carrying the carbide dissolved in it.

On cooling down it remains in practically the same condition until about 890° C. is reached. Now the α-iron begins to separate out from the solution, as pure water-ice would from weak brine. As the temperature falls still further, more and more α-iron separates (as more and more ice would), while the carbon concentrates in the residual solid solution (salt doing the same in the residual briny mother liquor) until at 690° C. a temperature is reached where it is impossible to keep the α-iron and carbide in mutual solution, so that this residual solid solution splits up into its constituents of α-iron and carbide side by side, forming pearlite, in the same way as at the eutectic temperature (— 23° C.) the water and salt can no longer remain in mutual solution, but splits up into its constituents of ice and salt forming the eutectic.

In the steel, however, this separation has taken place from the solid solution instead of from the liquid solution, and to distinguish the two cases the constituent in the steels is termed the eutectoid. The name given to this constituent of steels is pearlite simply from its pearly appearance when seen under moderate magnifications, and is due to its consisting—as most eutectics do—of finely interstratified laminæ or plates. This pearlite is found by analysis to consist of 0.9 per cent carbon, and is a mixture of 13.5 per cent iron carbide and 86.5 per cent iron.

In the light of the above we can thus readily interpret the cooling and separation sequence in steels. The case of mild or low-carbon steels ("unsaturated steel" of Arnold) has just been stated.

With the high-carbon steel (hypereutectoid of Howe, or supersaturated of Arnold) carbide in excess of the eutectoid proportion separates out first (bD of Fig. 1), the remaining mother solid solution becoming richer and richer in iron contents until the eutectoid proportion and temperature are again reached, when carbide and α-iron separate out alongside as pearlite.

[a] Carpenter and Keeling, "Range of Solidification and Critical Ranges of Iron-Carbon Alloys," *Journal of the Iron and Steel Institute*, 1904. No. 1, p. 232.

The operation of quenching is to hurry the cooling materials so quickly past these critical ranges as to tend to keep them in the condition prevailing at the higher temperature—that is to say, to retain the carbide in the form of a solid solution, or something equivalent, by preventing the separation of the constituents which would otherwise occur. It is thus found that the microscopic character of such quenched materials corresponds somewhat to that revealed by etching at high temperatures.

It may be further explained here that the terms martensite, sorbite, troostite, etc., are the names by which those appearances are distinguished when instead of the drastic quenching just indicated, the methods of cooling is so modified as to allow of a partial separation from solid solution. Thus sorbite is an unsegregated pearlite, due to the quenching operation being carried out in such a manner as not to have permitted the eutectoid the opportunity of separating out in interstratified laminæ. By rather rapid cooling through the critical range the cementite of the eutectoid is seen in small granules instead. Troostite, again, is a solid colloid solution of cementite in iron—in other words, a pearlite having ultramicroscopic particles of cementite.[5]

It is thus possible to have a whole series from the austenite solid solution through the colloidal stages down to well-laminated pearlite, by modifying the heat treatment. By prolonged annealing, indeed, the carbide of the pearlite may coalesce into separate flocks in a matrix of ferrite.

It will, therefore, readily be understood how such modifications of heat treatment, which affect the manner and extent to which the carbide separates from solid solution, must in their turn modify the properties of the resulting products, giving us the range from harder and more brittle to softer and more ductile material.

Finally, it may be remarked that the explanations given above are simply a résumé of innumerable observations and results reduced to the lowest possible terms, so as to give a practical explanation to this very complex and intricate mechanism during cooling. There is much that might be added to amplify fully these views. The object of the paper is, however, to place such a construction upon the accumulated evidence that both scientific and practical men can, with a greater amount of ease, develop the explanation along the same lines to meet special cases or points of detail which are of particular interest.

### Cast Irons.

It will be remembered that in the case of steels, whereas mutually insoluble carbide and α-iron represent the eventual stable conditions, the steel solidified first as a solid solution—a meta-stable form. Similarly in the case of cast irons, where as graphite and iron represent the eventual stable condition, the cast iron solidifies or tends to solidify as iron-carbide and iron —again the meta-stable form.

The science of carbon steels is the study of the conditions accelerating or retarding this change from meta-stable solid solution first obtained to the stable forms, in order to control the properties of the material and render it suitable for the particular purpose in view. In a similar way the science of cast irons is the study of conditions which accelerate or retard the change from the meta-stable iron: iron-carbide alloys tending first to be produced to the stable iron-graphite system —again in order to control the properties of the metal and to render it suitable for the special purpose for which it is to be employed.

In both cases, the properties of each end of the series are known; it is a matter of accumulated experience with equilibrium partially restored which enables the worker to know what constitution of metal is required for any particular case.

It is important, therefore, to consider generally what are the conditions which accelerate or retard this change from the

[5] C. Benedicks, Journal of the Iron and Steel Institute, 1908, No. 11, page 255.

primary meta-stable form on separation to the secondary stable form; and it will be found that in the main the general conditions are the same for cast irons as for steels.

*Conditions tending to bring about or restore equilibrium—*

1. *Slow Cooling* gives time and opportunity for changes from unstable to stable condition to occur. Examples in the case of the slowly cooled steels and cast irons are familiar.

*Prolonged retaining* of the materials at or a little below the critical range of temperature has the like effect.

2. *Reduction or Relieving of Pressure* tends to restore equilibrium.[6]

3. *Modification of Chemical Composition.*—It is possible by alteration of chemical composition to produce the stable forms from solution, or by decomposition.

*Conditions tending to prevent equilibrium—*that is, tending to retain materials in the unstable form—are, conversely

1. *Rapid Cooling or Quenching.*

2. *Increase of Pressure.*

3. *Modification of Chemical Composition* such as may tend to increase the solubility or to prevent decomposition of the chemical compounds originally existing in the meta-stable form.

Reverting now to the case of cast irons. They are regarded as alloys of iron and iron-carbide, the latter constituent being prone to decomposition during or after solidification, giving rise to graphite and a corresponding large amount of free iron.
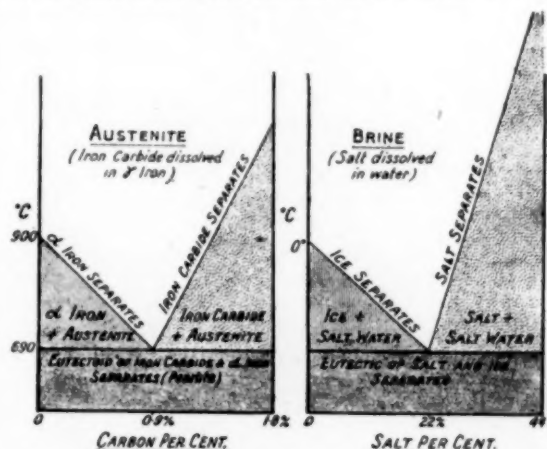


FIG. 2.—SHOWING ANALOGY BETWEEN SOLUBILITY OF IRON-CARBIDE IN α-IRON, AND OF SALT IN ICE.

The formation of gray irons by slow cooling and the formation of black-heart castings are readily understood, while the connection between heat treatment and constitution is apparent.

This conception necessitates a new and important way of regarding cast irons. Take, for example, a metal containing 3.5 per cent of total carbon. If this be regarded as primarily an iron: iron-carbide alloy it really consists of

$$\frac{3.5 \times Fe_3C}{C} = \frac{3.5 \times (3 \times 56 + 12)}{12} = \frac{3.5 \times 180}{12} = 3.5 \times 15 = 52.5 \text{ per cent iron carbide.}$$

before and at the instant of solidification.

That is, in cast irons the combined carbon should not be regarded, so far as its effects on the metal are concerned, as so much per cent combined carbon, but as 15 times that percentage of iron-carbide. This point of view will at once make clear the meaning of many observations and results, some of which have hitherto been more or less obscure. For instance, that 3.5 per cent of combined carbon in a white iron should be unstable does not appear to the imagination so forcibly as does a metal consisting of no less than 52.5 per cent of meta-stable iron-carbide.

Its ready decomposition by heat appears much more understandable, as well as the marked difference in properties accompanying even such seemingly small changes as, say, 0.1 per cent of combined carbon converted into graphite. Such an

[6] C. Benedicks, supra.

alteration, however, really means the disappearance of as much as 1.5 per cent of the hard, brittle iron-carbide and the simultaneous setting free of 1.4 per cent of soft, ductile, free iron. Changes in carbon condition in reality are magnified no less than 15 times.

### The Solidification Sequence of Cast Irons.

It will be seen from Fig. 1 that up to about 4.3 per cent carbon (64.5 per cent carbide) austenite separates first from the liquid metal.

Taking as an example a cast iron of the usual carbon contents of 3.5 per cent, the austenite separates at a temperature of about 1230° C. (N, Fig. 1) in the dendritic form usual in such cases. As the metal cools down these dendrites grow as more and more austenite separates, while the excess carbide remains behind, becoming more and more concentrated in the residual mother liquor. Eventually at 1136° C. (M, Fig. 1) this remaining liquid solidifies in between these dendrites in the form of an eutectic of austenite and iron-carbide, containing 64.5 per cent of the latter constituent (= 4.3 per cent carbon). The whole mass is now solid. On further cooling the austenite portion, containing about 13.5 per cent carbide (1.5 per cent carbon) in solid solution, gradually deposits its excess of cementite at its crystal borders, until just above Ar (690° C.) there is only 0.9 per cent carbon left in solid solution. At this temperature, as has been already seen, the pearlite change occurs, the solid solution finally depositing α-iron and carbide alongside each other in the form of the eutectoid pearlite. In such cast iron, therefore, the dendritic pearlite (surrounded with its border of cementite) marks the position of the primary austenite crystals, which first separated at NM.

A cast iron containing 4.3 per cent carbon (64.5 per cent carbide) tends to solidify wholly at 1130° C. as an austenite-cementite eutectic.

With cast irons containing more than 4.3 per cent carbon the first constituent to solidify would be the iron-carbide in excess of the eutectic proportion; then at 1136° C. the austenite-cementite eutectic separates as before, and the subsequent changes take place as already indicated. Now up to 4.8 per cent of carbon such results can be obtained with pure iron-carbon alloys on quenching.

Reference might be suggested to the numerous and excellent photographs of Benedicks, Goerens, Heyn, Howe and Tieman, Longmuir and McWilliam, Sauveur, Stansfield, Stead, Wüst, and many others.

Under ordinary cooling conditions, however, such results are not obtained, graphitic irons resulting, the reason being due to the ready decomposition of the carbide, particularly at high temperatures. The conditions which tend to accelerate such a change have already been pointed out, and are well known, but the exact mechanism of this change can now be brought to mind in a simpler manner than has hitherto been possible.

The tendency to decomposition of a metal containing something between 55 to 65 per cent. of unstable carbide during solidification will be apparent, especially bearing in mind the very high temperatures prevailing; and there is the further well-known fact that once the meta-stable condition is broken down, restoration to equilibrium proceeds much more rapidly and completely, so that in the present instance, once graphite has been produced in the metal, the production of further quantities rapidly follows.

With regard to the mechanism of this change, it is well known, and has often been recorded, that even in the solid condition, especially at high temperatures, the various constituents of alloys tend to migrate and coalesce into larger and larger masses.[1] Even the cementite constituent of pearlite behaves in this way. It has been further shown by Arnold[2] and McWilliam that eventually such large masses of cementite decompose, graphite being produced in the centre of the areas, whilst

surrounding it is the iron, which is the other product of this decomposition of the carbide. It is this process which appears to go on in the formation of secondary graphite on slow cooling.

Further than this, the production of kish in high carbon irons, the formation of primary graphite, as well as the limit to the total carbon contents of ordinary cast iron, can be readily understood from this point of view.

During the actual solidification in such irons, the carbide which is in process of solidification tends to decompose. This iron-carbide has a density nearly similar to that of the liquid metal, so that, could it remain undecomposed, it would stay in the position in which it had been deposited. But graphite has a density of only about 2.0, so that being so much lighter than the liquid metal, it tends to rise to the surface, forming kish, and by this means the total carbon contents of the melt is decreased to this extent.

Since, however, such graphite is surrounded by a corresponding amount of iron from the $Fe_3C$, there may be some tendency for it to be held back in the material, this depending largely on the composition, temperature, fluidity and other conditions of the metal. An important consideration is that the dendrites of primary austenite which form first would help to entangle this graphite.

It will be readily seen why iron-carbide alloys containing more than, say, 4.5 per cent of carbon cannot be obtained under ordinary working conditions. Not only would such strong solutions of 68.0 per cent and upward of carbide in the liquid condition readily decompose at these high temperatures (much as strong sugar solutions, such as syrups, do), but on solidifying carbide would separate first, would instantly decompose, and the lighter graphite immediately rising to the surface of the liquid mass would lower the total carbon contents.

Below the eutectic proportion of 4.3 per cent carbon this does not occur so readily, but owing to this decomposition the tendency remains to lowering of total carbon contents by this means, though by the action of the primary austenite dendrites indicated at the left-hand side of the eutectic proportion such a tendency is checked mechanically.

The considerations dealt with above have had reference chiefly to the connection between the temperature and constitution of cast irons. The effect of pressure has not been investigated so fully, but such results as have been obtained bear out the views as stated previously.

The effect of chemical composition is most important from the practical point of view. The cast irons in practice contain considerable amounts of other elements, such as manganese, silicon, sulphur, and phosphorus; and these constituents, or at least the first three, in the quantities in which they are present in cast irons, exert a profound influence on the relations between carbon and iron.

One point deserves special attention. Sulphur, silicon, and phosphorus do not exist, as such, in cast irons, but the sulphur combines with any free iron, which may be present to form iron-sulphide, the silicon also combining with iron to form iron-silicide, $Fe_2Si$, in cast irons of ordinary composition, while the phosphorus similarly forms a phosphide. The first effect of these constituents (apart from reactions with manganese) is therefore to decrease the amount of uncombined iron which otherwise separates as primary austenite.

### The Effect of Foreign Elements on the Condition of the Carbon.

Bearing in mind the fact that the carbon in the iron-carbon alloys tends to separate as carbide according to Fig. 1, and that this carbon tends to decompose into graphite and iron, the action of the common elements in commercial cast irons may, for the present purpose, be summarized as follows:

A. Tending to bring about Equilibrium.

To accelerate change from meta-stable carbide to stable graphite. Silicon

[1] J. S. Stead, "Migratory Habits in Alloys," Journal of the Society of Chemical Industry, March 31, 1903.
[2] Arnold and McWilliam, "Thermal Transformations of Carbon Steels," Journal of the Iron and Steel Institute, 1905, No. II, p. 27.

B. Tending to retard Equilibrium.

    To prevent change from meta-stable carbide to stable graphite.                Sulphur (by itself).
                                   Manganese (by itself).

C. Neutral action.

<center>Phosphorus</center>
<center>Manganese and Sulphur together</center>

    (when in such proportion as to form MnS).

*Silicon.*—Although the relations between silicon and the condition of the carbon have not yet been sufficiently studied chemically and physically to allow of reactions being stated with any pretension to exactness; generally speaking, silicon appears to act upon the combined carbon in cast irons in two ways, amongst others—

    a. It lowers the solvent power of iron for iron-carbide (probably as $Fe_2Si$).

    b. It probably tends to decompose carbide according to the following reaction—

$$Fe_3C + Si = Fe_2Si + Fe + C.$$
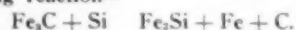
It will be seen, therefore, why the increase in silicon contents tends to lower the total carbon contents of cast irons, and leads also to the formation of graphite.

    Taking as example a 4.2 per cent carbon cast iron. Melted with a moderate proportion of silicon, the carbide is thrown out of solution, is decomposed at the high temperatures prevailing, and a corresponding quantity of graphite is formed. On chilling the metal quickly, such graphite is retained *in situ*, and a "whitish" iron results, containing graphite according to the amount of silicon added. If such metal be kept melted for some time, and the graphite allowed to rise to the surface, and to thus separate as kish, then on chilling, a white iron results (if the silicon has not been too high). This iron is of lower carbon contents, however, because of the graphite kish separated (formerly in solution as carbide). If slowly cooled, such metal is gray, and also has a lower total carbon content.

It will be seen, even in this case, how largely the total carbon contents of cast irons depend on the stability of the iron carbide; for had this remained stable and unchanged on separating from solution apart from its decomposition by the silicon (see *b* above) the total carbon contents of the irons could not have been affected, because the separated carbide, by reason of its density, would have remained unchanged where it was, instead of separating out of the melt altogether as graphite, which rises on account of its lightness.

Many experimental facts[*] may be quoted in support of this view, which is here given in the most condensed form.

*Sulphur* and *manganese*, each considered separately, tend to retain the carbon in the combined form, preventing its conversion to graphite and free iron.

*Sulphur* as sulphide of iron acts mechanically and physically in such a way as to oppose the conditions which favor the decomposition of iron-carbide, from which graphite results; physically, by a lowering of melting points and by surface tension and mechanically, by forming sulphide films and envelopes around the cementite crystals. If these crystals, which separate as a constituent of the 1130°C eutectic, 4.3 per cent carbon (DE, Fig. 1) were free, they would coalesce and eventually decompose under favorable conditions. These minute sulphide films, however, having a high surface tension, tend to emulsify this cementite, thus retarding those necessary stages prior to its decomposition. It is, moreover, probable that these emulsifying envelopes of sulphide, acting in opposition to the expansion which accompanies the formation of graphite from carbide, still further retards the change.

The effect of manganese on the iron-carbon alloys is a subject to itself. For the present purpose it may be stated that in the quantities usually found in cast irons, manganese tends to the formation of carbides, which are very stable—as

[*] Charpy and Grenet, *Metallographist*, 1902, Vol. V, p. 202; Wust and Peterson, *Metallurgie*, 1906, Vol. iii, p. 84; also Turner's papers and many others.

first readily shown by Arnold. In other words, while iron carbides are readily decomposed by heat into graphite and free iron, manganese carbides are not, but remain stable and unchanged; so that the carbon remains in the combined form.

This fact has important applications in practice in several ways. Owing to the stability of the manganese carbides in cast irons, such alloys are kept white and hard by additions of much manganese and, therefore, more difficult to soften by heat treatment alone—especially if the silicon contents be not high. Again, when high proportions of manganese are present, not only are the white, stable, and brittle alloys familiar as ferro-manganese and spiegeleisen obtained, but the carbon contents of such irons is much higher than in the ordinary metal which, as just seen, has a limiting value under ordinary conditions of 4.5 per cent carbon. This is because, even on heating to the melting point, the double carbides of iron and manganese are so stable as to be undecomposed; and on melting and slow cooling they again remain as carbides, white and unaltered.

Although the same principles as regard solution of the carbon as carbide exist as in the iron-carbon series, there is no secondary decomposition of carbide to consider. No matter, therefore, how high the carbon content be—up to about 5.5 to 6.0 per cent carbon in the liquid metal—since the carbide does not decompose on solidification, graphite is not formed, and hence does not separate from the metal as kish; so that the total carbon contents are not lowered at all by this cause.

It has been indicated recently that when manganese and sulphur are present wholly as manganese sulphide, this neutral body has but little action either way on the relations of the carbon and iron. Its tendency, if any, would be towards the retarding of equilibrium, in that some of the manganese sulphide tends to separate with the 1130° C. eutectic; so that some slight mechanical action might take place. Manganese added to a sulphurous iron or sulphur added to a manganese iron tends, therefore, towards neutralizing the retarding of graphite formation, caused by either acting alone. But either element in excess of the proportions required to produce MnS will naturally exert its own specific action—particularly sulphur in excess; because not only does this excess sulphur form iron-sulphide, which acts as already indicated, but this iron-sulphide carries some of the manganese sulphide with it to act together in this way, so that the effect of excess sulphur is much magnified.

The action of phosphorus may be followed from the valuable researches of Stead and Wüst.

The action of manganese and silicon together is not yet thoroughly investigated. Fletcher has, however, done much good work in this direction; and research is in progress bearing on the subject at the University of Birmingham at the present moment.

The study of the action of sulphur and silicon together is a stupendous piece of work, which has not been dealt with very fully so far, but which promises important practical results.

In conclusion, it will be recognized how, commencing with this conception of the primary condition of cast irons and carbon steels, it is possible to arrive at a systematic corelation of the effects of constituents and heat treatment in the industrial alloys. By standardization work, and by ascertaining the definite conditions which retard or accelerate the all-important changes from the meta-stable condition primarily existing to the final stable forms, it is possible to define the exact conditions necessary for the attaining of desired composition and of desired properties of metals for specified purposes.

**Appendix.**—The development of the iron-carbon equilibrium diagram.

Largely to the manipulative skill and the genius of Roberts-Austen, Standfield, and Le Chatelier, we owe the conception of metallic alloys as being closely analogous to ordinary saline solutions.

These workers were enabled from their freezing point

diagrams to place iron-carbon alloys also in this class, regarding irons and steels as solutions of iron and carbon.

Roozeboom's application of the phase rule introduced a general law governing these alloys regarded as an iron-carbon series, and especially valuable was his addition of the solidus curves, which assists in following closely the solidification sequence. This work resulted in the conception of a diagram representing the equilibrium between iron and carbon in these alloys. But since such a diagram can only represent components in their stable form, it dealt only with iron and carbon in the elemental condition; while in order to account for the occurrence of combined carbon in many cast irons it was assumed that at certain high temperatures iron and carbon were capable of combining and forming a stable compound iron-carbide.

This theory, contrary to all practical observations, was abandoned soon after. The admirable work of Heyn, Wüst, and Benedicks, chiefly brought out the idea that there were two systems of alloys in irons and steels—one a labile or stable system, the iron-graphite series; the other meta-stable or unstable, the iron: iron-carbide series. Both were represented on a single diagram with the usual liquids and eutectic lines. The explanation of this view is that although in the sense of the phase rule, iron and graphite are the stable phases of the series, the carbide, though unstable often shows a strong tendency to remain as such after solidifying in this condition.

The separation of the carbon in the combined form, as carbide, on solidification was considered as an abnormality, and as being due to its tendency to meta-stable equilibrium, and it was considered that, normally, carbon seperates from solution in iron in the graphitic form.

This view led to some vagueness and difficulty in giving definite reasons for the constitution of the cast irons met with in practice, and especially for the changes in the constitution brought about by alterations of chemical composition and by the rate of solidification and cooling; it being explained that slow solidification and presence of certain elements encouraged the solidification of carbon in the graphitic or stable form, rapid solidification and the presence of other elements, on the other hand, encouraging the stability of the meta-stable cementite on solidification.

In the case of cast irons and steels the rigid application of the phase rule is, however, barely possible and almost unwise, and the utmost caution is necessary in applying it in the present instance if it is desired to utilize it in connection with the problems of everyday practice. For the equilibrium diagram can only deal with phases in stable equilibrium, and it can consequently only give indications as to what results might be expected if graphite separated directly from cast irons, and if alloys of iron and graphite only had to be dealt with. This is, however, only the very ultimate condition of such alloys, and with this one has, generally speaking, little to do in practice.

The problems of practical working are those connected with the presence of cementite, and the conditions which tend to keep it in that form, or which change it from that form. If now we can consider cast irons and carbon steels as solidifying primarily as alloys of iron-carbide and iron, there is to hand at once a rational and definite method of considering what subsequent changes occur to this carbide which result in the alloys used industrially.

An equilibrium diagram is inapplicable to the case, because the bringing about of true equilibrium, which can only be effected by the decomposition of the unstable carbide to stable graphite, occurs over practically the entire range of temperatures covered by such a diagram. It is, moreover, enormously influenced by considerations of time, pressure, surrounding medium, etc., which effects can find no direct interpretation on such a diagram. On the other hand, if iron-carbide be regarded as the constituent which solidifies primarily from

cast irons and steels, it is possible to consider in a positive and definite manner what conditions affect its decomposition, yielding the graphite and remaining carbide which are found in the commercial irons. It is the admirable experimental research of Goerens which has finally established this primary separation of iron-carbide as a fact, and therefore enables us, with confidence, to consider cast irons and carbon steels as being primarily alloys of iron and iron-carbide.

UNIVERSITY OF BIRMINGHAM.

## Standardization of Metallurgical Terms.

The committee appointed by the council of the Chemical, Metallurgical and Mining Society of South Africa to consider the advisability of furthering the standardization of metallurgical terms and phrases, has made a preliminary report in which suggested changes are made. While many of the suggestions relate primarily to Rand practice, they are, nevertheless, of more universal application, and will tend to clarify technical writing.

1. Except when otherwise necessary, the following words shall be treated as collective nouns, and therefore used in the singular: Sand, tailing, fine, black sand, residue, ash, pyrite ($FeS_2$), concentrate, slag, sulphide, telluride, slime, chloride.

2. The following terms shall be used in the plural form to indicate the products: Shavings, skimmings, steamings, sweepings, drillings, reserves.

3. Preference should be given to the singular form in: Precipitate, bin, cost, profit, value.

4. Such abbreviations as the following shall not be printed in the plural: oz., lb., dwt., gr., cc., cm., kg., in., gal., m., gm., mm.

5. As far as practicable the following terms shall be avoided: Dirt, mullock or muck (broken ore or waste), kokopan (truck), cheesa stick (firing stick), lasher (shoveler), lashing (shoveling).

6. The following spelling shall be used consistently: By-product, shoot (the geological term), by-pass, hydraulicking, siphon, chute (passage or opening through which material is guided), kafir, gram, dike, rise.

7. Vat shall be used in place of tank; cyaniding in place of cyanidation; breaking and sorting in place of crushing and picking; crushing shall imply stamp-milling plus tube-milling; ore slime shall be used to distinguish from gold slime; extraction shall refer to metal extracted from ore; precipitation shall refer to metal precipitated from solution; recovery shall refer to metal won in a form suitable for market.

8. In referring to screening it should be stated whether number of holes refers to the square or linear inch, and the diameter of the aperture in decimals of an inch should be given; battery screenings should have the gage of wire in decimals of an inch and the percentage of discharge area mentioned, whenever possible. Temperatures shall be expressed in degrees Centigrade (with the equivalent in Fahrenheit in parenthesis). Cyanide and alkali strengths shall be expressed in terms of specified reagents, thus: 0.05 per cent KCN; 0.02 per cent NaOH; 0.02 per cent CaO.

9. A ton shall be 2000 lb. A fuid ton shall mean 32 cu. ft.

10. The following scheme illustrates the nomenclature of Rand reduction works:
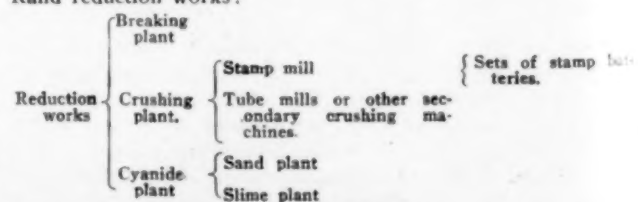


Zinc box precipitate may be refined with a solution of sulphurous acid as well as sulphuric. The action is a little slower, but it has the advantage of being inexpensive, and is adapted to isolated places.

## Death of Oscar Guttmann.

It is with sincere regret that we have to record the death of Mr. Oscar Guttmann, the well-known expert on explosives, of 60 Mark Lane, London, E. C., which took place with painful suddenness at Brussels on Tuesday, Aug. 2. He was one of the British Jurors at the Brussels Exhibition and on Tuesday was being driven in a taxicab to the Gare du Nord, when his conveyance was struck by another automobile and he was thrown out and his skull fractured. He was conveyed in an insensible condition to the Hospital of St. Jean, but did not rally, and died within a few hours.

Mr. Guttmann was born in the year 1855, and at a comparatively early age showed his remarkable capacity for literary work of a technical character. His connection with the explosives industry commenced with the Hungarian Explosives Works of the Nobel Company, where he laid the foundation of the extensive knowledge which he afterwards showed in his professional duties. He was a recognized authority on all matters associated with the chemistry and manufacture of explosives, and the erection of factories and chemical works, and in connection with these subjects he was the author of a number of books, papers, pamphlets and lectures. In these matters he was considerably helped by his linguistic attainments, being able to speak and write in some six different languages.

From 1874 to 1885 he was technical adviser and constructor of plant of various large works in Austria-Hungary, including the St. Lambrecht Dynamite Works and the Budapest Gunpowder Works. He then undertook the management of an explosives works at Isleten (Switzerland), which he organized and brought to a state of prosperity, this factory supplying the dynamite used for the blasting of the St. Gothard tunnel. After a short time he was entrusted with the management of the Italian Dynamite Works at Avigliana, which he completely rebuilt after a disastrous fire, introducing many notable improvements in the construction of the buildings of the works.

In the year 1887 Mr. Guttmann came to England, and established himself as a consulting and chemical engineer in London, becoming naturalized in 1894. He soon acquired an extensive practice. His apparatus for the manufacture of nitric acid is well known, and there are many installations at work both in this country and abroad, the apparatus giving a quantitative yield of nitric acid of the highest concentration. Guttman's reaction tower for chemical works is equally well known. It is filled with hollow stoneware balls with cup-like indentations, or with hollow cellular bodies of rhombohedral shape, and ensures a most intimate contact of gases with liquids.

Mr. Guttmann designed and built the large works of the National Explosives Company at Hayle, Cornwall, for the manufacture of dynamite, blasting gelatine and cordite, the English Government's smokeless powder, which were subsequently managed by him for several years. He also designed and erected the Acetone Works at Waltham Abbey, Woolwich, Clapton and Manchester, the testing station for mining and safety explosives at Reichenstein, Germany; sulphuric acid works in Australia, India and Mexico, the latter also including concentrating and recovery plant, and many other chemical works of all kinds in the United Kingdom, Germany, Italy, Austria-Hungary, Belgium, France, Norway, Russia, Holland, Switzerland and the United States.
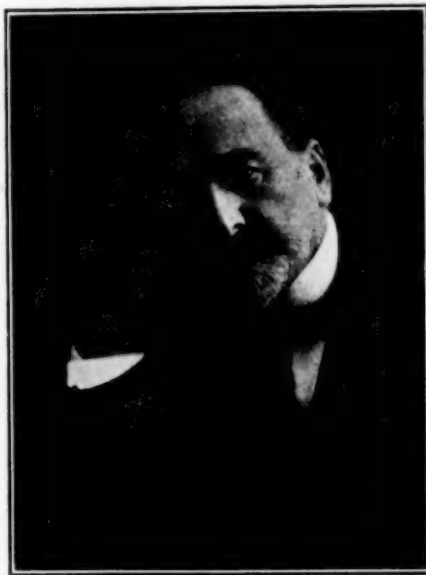
But he is best known by his classic works on the "Manufacture of Explosives" and on "Blasting," which have also been published in German. Recently he delivered before the Royal Society of Arts the "Cantor Lectures" on the "Manufacture of Explosives: Twenty Years' Progress." These have been published in German as a separate work, which is remarkable for its comprehensiveness and beautiful illustrations. As a member of the committee for explosives at the Seventh International Chemical Congress held in London last year he took a leading part in the preparation of a book entitled "The Rise and Progress of the British Explosives Industry," the idea of its preparation being due to him and the book being published on behalf of the committee. The articles on explosives in most standard works of reference, such as Muspratt's "Chemical Technology" and Lunge's "Technical Methods of Chemical Analysis" were written by him. Mr. Guttmann published a very large number of technical papers, most of which appeared in the *Journal* of the Society of Chemical Industry, in the *Proceedings* of the Institution of Civil Engineers, and in a large number of technical journals. His unique experience in explosives and chemical manufactures naturally caused him to be frequently called as an expert in law cases of a technical nature, some of these such as Maxim v. Anderson, St. Helen's Corporation v. the United Alkali Company being of far-reaching importance.

He devoted his spare time to the study of the history of explosives, and made frequent and extensive journeys with a view of examining rare manuscripts. In this branch of historical research he was an acknowledged authority. The result of these investigations appeared in technical journals from time to time as occasion offered, and they were recently collected by him in a magnificent folio volume entitled "Monumenta Pulveris Pyrii," and richly illustrated with prints from his private collection. His latest contribution to the history of explosives appeared only a few days ago in the *Chemiker Zeitung*, and in another paper now in the press he had described the safe construction of buildings in explosives works. It must be noted as characteristic of him that although he had patented this latter construction he allowed the free use of it to the public without demanding a royalty.



OSCAR GUTTMANN

He was a member of the Institution of Civil Engineers, which awarded him the Telford premium for a paper on "The Blasting of the Iron Gates of the Danube," and highly commended a long paper elaborately illustrated with scale working drawings on "Machinery Used in the Manufacture of Smokeless Powders"; a fellow and vice-president of the Institute of Chemistry, and twice a member of council of the Society of Chemical Industry.

As a freemason he held a conspicuous position. He was W. M. of the Pilgrim Lodge, No. 238, and it was chiefly at his instigation, and afterwards due to his indefatigable exertions, that the combined meeting of the Anglo-Foreign Lodges took place with singular success last March. In April last the United Grand Lodge of England invested him as a past senior grand deacon, and though he highly appreciated the distinguished honor conferred upon him, and thereby upon the Anglo-Foreign Brethren, it is stated in the current issue of *The Freemason* that he specially requested that no particulars of his Masonic career leading up to this distinction should be given in its columns. In a brief summary of the united meeting, *The Freemason* writes: "There was a complete consensus of opinion that Brother Guttmann, as W. M. of the enter-

taining lodge, Pilgrim, was the right man in the right place. Everything in word and action was so natural and unrestrained that it was a pleasure to witness the ease with which all was accomplished. Undoubtedly much of the success was due to his intuitive tact and ability."

His death will be mourned by a large circle of friends whom he was ever ready to assist, and by his younger colleagues, to whom he was ever ready to lend a helping hand or to give friendly advice, and many of whom now hold positions due to his influence. He was well known to many American chemists and manufacturers, several of whom are among his clients. He leaves a widow, two sons and one daughter. The latter has devoted herself to painting; his elder son, Dr. Leo F. Guttmann, was for three years instructor in chemistry at the College of the City of New York, and is now assistant professor of industrial chemistry and chemical engineering at Queen's University, Kingston, Canada: his younger son is a civil engineer. One may expect, therefore, that his sons will carry on their father's practice.

A large circle of friends attended the funeral, Freemasonry being represented by Sir Edward Letchworth, secretary of the Grand Lodge of England, and by delegates from the lodges Pilgrim, La France, Entente Cordiale, Deutschland, Italia, America and Prosperity, and from the International Masonic Clubs. The Society of Chemical Industry, Institute of Chemistry, Society of Public Analysts and Institution of Civil Engineers sent their presidents or vice-presidents, and nearly all members of council in town showed their personal loss by being present. Nobel's Explosive Company, Woolwich Arsenal and the British Board of Trade also sent representatives.

Among the numerous wreaths sent by the learned societies and lodges was one, which was particularly appreciated, bearing the words: "He was a perfect Mason, a loyal friend, earnest and sincere; a light has left us that will shine on in the great mansions above." It was sent by Mr. Van Duzer, P. M. Lodge America.

## San Francisco Meeting of the American Chemical Society.

The San Francisco meeting of the American Chemical Society marks a milestone in the career of the society.

A plastic story of the trip of the Eastern members to San Francisco, from the pen of a distinguished chemical engineer and particularly good friend of this journal, will be found in the correspondence columns of this issue. An illustrated account of the only marring incident of the voyage—the wreck of the special train with the marvelous escape of all passengers—was already given on page 446 of our last issue. We herewith give a concise account of the San Francisco meeting itself.

On Wednesday morning, July 14, the forty-second general meeting of the American Chemical Society was called to order by President Bancroft in the St. Francis Hotel, San Francisco. After an address of welcome by Dr. Arthur Lachman for the California Section, responded to by President Bancroft, the following addresses were delivered in general session:

Dr. W. D. Bancroft: Positive photography. This lecture was illustrated with lantern slides.

Dr. Edw. C. Franklin: Liquid ammonia as a solvent and the ammonia system of acids, bases and salts.

Dr. W. F. Hillebrand: Chemistry in the Bureau of Standards.

Dr. H. E. Barnard: The use of sodium benzoate as a preservative of food.

At the same time a ladies' reception was held in the parlors of the St. Francis Hotel.

After luncheon the members present and their guests enjoyed an excursion over the Ocean Shore Railroad to Half-Moon Bay and Tunitas Glen, returning in time for the smoker held in the Fairmont Hotel and the ladies' theater party. A hot supper had been promised at the smoker and all who partook of the tomales and heard the Chinese music were ready to acknowledge that the adjective was quite descriptive.

On Thursday morning the meetings of the divisions were held in the St. Francis Hotel, and many interesting papers were presented. The symposium on smelter smoke before the Industrial Division excited special interest.

After luncheon all attending the meeting enjoyed one of the pleasantest excursions of the trip, made by special train to the top of Mount Tamalpais and through the Muir Woods, and the members were entertained at a banquet during the evening on the top of the mountain. Several of the members remained all night, coming down the mountain on the following morning in gravity cars. This grove of redwoods, named after John Muir, is probably one of the most beautiful bits of scenery in the immediate vicinity of San Francisco, and the ride to the top of the mountain with the changing interest of foliage and panorama of hill, valley, bay and distant city of San Francisco was appreciated by all.

Friday morning was spent at the University of California, in Berkeley, mainly in an examination of the various buildings, laboratories and campus of this beautifully situated institution. The party then took a special steamer as the guests of the Selby Smelting & Lead Company, being entertained at luncheon by the company and afterward conducted through their plant, where the various processes of lead smelting and the recovery of gold and silver therefrom were explained. One of the chief attractions of this plant was the opportunity given to view the new Cottrell precipitating apparatus installed for the purpose of removing sulphur trioxide and any other solids or liquids present in smelter smoke.

After returning to San Francisco the evening was spent in a visit to Chinatown, where at 10 o'clock all were entertained at a Chinese collation of tea and sweets served in a Chinese restaurant to music which the local committee characterized as sweet.

Saturday morning was devoted to divisional meetings at which the remaining papers on the program were read.

In the afternoon, at 2 o'clock, the members were treated to an automobile ride over Buena Vista Heights, through the Golden Gate Park to the ocean beach and the Cliff House, returning through the Presidio and the residential section of San Francisco.

In the evening the members all assembled for the main banquet of the week in the St. Francis Hotel, at which all of the ladies attending were guests. About 250 sat down to the banquet, which will long be remembered by all present.

On July 17 the party, as the guests of the Italian-Swiss Colony, took a special train to Asti, where an unusually pleasant day was enjoyed in examining the vineyards and wineries of this well-known section. The lunch was served outdoors in attractive pergolas. The party returned to San Francisco early in the evening and were given, almost for the first time, opportunity to sleep.

On the following morning, July 18, an excursion was taken by steamer up the Sacramento River to Sacramento through the wonderfully fertile fields of the Sacramento Valley, between levees so high that the party was obliged to view the country from the upper deck of the steamer. The general aspect was much like that of portions of Holland. Returning from Sacramento by train, the party reached San Francisco late in the evening, having been royally entertained. Many, however, took train at Sacramento for the north.

On Tuesday, July 19, a special steamer was provided for those who remained to visit and examine the various points of interest around San Francisco Bay.

Following the meeting in San Francisco, the members returned to their homes by various routes, but some 30 traveled northward by invitation of the Puget Sound Section to visit Seattle and obtain a view of the Northern Pacific Coast scenery. Arriving at Seattle on the morning of the 21st, the party was met by President Falkenburg, of the Puget Sound Section;

Mr. Horace G. Byers, councilor of the section; President Kane, of Washington University and others, who welcomed them as the guests of the Puget Sound Section.

On arrival the ladies were supplied with bouquets of dahlias and shortly afterward all started on an automobile trip which covered all parts of the city, both business and residential, and included the beautiful grounds of Washington University.

At the end of the drive the party were lunched at the Commercial Club, after which they immediately left on a chartered steamer for a trip around Puget Sound. The first stopping point was the plant of the Pacific Creosoting Company, where the party left the boat and inspected the largest creosoting plant in the world. Returning, a stop was made at the Navy Yard, where battleships and armored cruisers were examined, and then the party proceeded to Tacoma, where a delightful lunch was served under the enormous trees of the Tacoma City Park. By the courtesy of the Board of Park Commissioners the party was well supplied with roses and given permission to pick all the sweet peas they could carry away.

From Seattle some of the party came east via Vancouver and the Canadian Rockies, while others came over the Northern Pacific, visiting the Yellowstone National Park.

Unusual enthusiasm was shown throughout the whole meeting, and many new Western members were added to the society, which now has a membership of over 5000. Two hundred and ninety members and guests registered for the meeting.

One hundred and twenty papers were presented at the meeting, embodying new chemical research, many of them reporting important results.

## Notes on Chemistry and Metallurgy in Great Britain.

*(From Our Special Correspondent.)*

### The Synthesis of Ammonia.

Up to the present time the liquor obtained in the manufacture of coal-gas or from the coke ovens has been the sole source of ammonia, and its synthetic production has not been regarded as possible of attainment commercially. Attempts are being made to prepare ammonium salts from cyanamide, but even if these should meet with some measure of success the process would probably be too costly to prove remunerative. The Badische synthetic method is independent of electric power, and now that both hydrogen and nitrogen are obtainable with facility at a low cost it is by no means unlikely that the electrochemical processes of manufacturing cyanamides and nitrates will find in it a strong competitor in the production of fertilizing material; but the available information hardly justifies a definite forecast, although there is apparently a fair prospect of success for the new process.

It is stated that the Badische Anilin & Soda Fabrik has solved the problem of the direct production of ammonia from its elementary constituents, and will probably soon effect the preparation of synthetic ammonia on the commercial scale. Professor Haber and M. R. le Rossignol, after much experimental work, found that at a high temperature and under a pressure approaching 200 atmospheres, the desired combination of hydrogen and nitrogen occurred and the action was increased by certain catalytic agents, particularly osmium, but, in consequence of the high price of this metal, uranium is used in practical working. The difficulties involved were great, but the Badische staff appears to have been successful in grappling with them. The mixed gases are compressed and brought into contact with the powdered uranium in a chamber where a pressure of 175 atmospheres is maintained at a high temperature, with the result that union of a large part of the mixture of gases takes place. The ammonia and the residual uncombined gases pass into a freezing apparatus whence the liquified ammonia is withdrawn, while the unchanged gases pass through and, with further quantities of hydrogen and nitrogen, are again treated in the pressure chamber. The heat evolved in the formation of the ammonia is utilized to assist in bringing the fresh mixture of gases to the requisite temperature. A satisfactory yield of ammonia is reported to have been obtained at the Badische works.

### Calcium Cyanamide.

From the report of the Gesellschaft für Stickstoffdünger, of Knapsack, for last year, it appears that the condition of the cyanamide industry, at least in the district supplied by this plant, is not very flourishing. The Westeregeln plant was running nearly all the year working up the carbide supplied under previous contracts into cyanamide, but a fluctuating demand necessitated the stocking of a large proportion of the output at considerable expense. Working costs were much increased at Knapsack by the employment of only a small fraction of the capacity of the plant. Agriculturists were slow in extending the use of cyanamide, and the excessive establishment of new factories had resulted in a total output greatly exceeding the demand, although the total turnover recorded by the Sales Association had improved 35 per cent, and the demand during this spring had been greater. The production of ammonium sulphate from cyanamide had not yet progressed beyond the experimental stage. The capital was £180,000, and the gross loss amounted to £12,900.

### Radium from Sweden.

The Swedish Radium Company has produced its first batch of radium bromide, weighing 5 centigrams, and is sending it to the Banque de Radium at Paris, with which bank the company has made an agreement for the reception of its entire output of radium. Gold tubes have been found deficient in resistance to the emanations, and the bromide is now secured in receptacles of platinum-iridium alloy. The "kolm" mined in Sweden has been found superior to radium-bearing material from Australia and America, both in respect of facility of manipulation and of content of radioactive substance.

### Slags in Iron and Steel.

By experimenting with specially prepared oxides, silicates and sulphides of iron and manganese, M. Matweieff has devised a method of ascertaining the composition of slags enclosed in iron and steel. The silicates of iron and manganese are not affected by organic acids nor by heating in hydrogen or superheated steam. The oxides of iron and manganese are also not acted on by organic acids, but are reduced by hydrogen. If the reduced metal be tested with a dilute alcoholic solution of ferric chloride, manganese without iron gives no reaction; iron gives a feeble coloration, and iron with manganese gives a strong coloration. The sulphides of both metals are acted on by organic acids, but hydrogen and steam have no effect. Tartaric acid gives a strong coloration with sulphide of iron, but only exerts feeble action on manganese sulphide.

### The Production of Rare Metals and Their Alloys.

M. P. Girod advocates the addition of a borate or of boric acid to the mixture of ore, reducing material and flux in the preparation of such metals as tungsten, tantalum, titanium, molybdenum and vanadium, claiming that a much more fluid mixture is thereby obtained from which the metal separates with greater facility, and that the metal is protected from oxidation by the coating of quite liquid slag. Valuable qualities are imported to the metal or alloy by the incorporation of a small proportion of boron, and by the addition of the requisite quantities of iron-titanium-boron alloy to ordinary steel special tool steels or constructional steels can be produced. This process is patented in France.

### Electro-Deposition on Aluminium.

It is reported that a German firm has solved the problem of electroplating aluminium, and has been successful with copper, silver, gold and nickel, but details have not yet been published. The rapid oxidation of aluminium by alkaline substances has

restricted its field of utility, and if this defect can be removed —as it would be by copper plating—engineers will be enabled to avail themselves to a much greater extent than formerly of the valuable properties of this metal.

### Regenerative Galvanizing.

The Cowper-Coles Galvanizing Syndicate has published particulars of the "regenerative" process, which consists in first depositing zinc by a special cold method and then applying a treatment which is claimed to produce a film of iron-zinc alloy which prevents rusting. The coating of zinc is said to be perfectly uniform and free from irregularities. In galvanizing by the hot process the threads of nuts and bolts are often filled up and the distribution of the zinc is almost always irregular. The new method is said to coat even fine-threaded screws without any re-tapping becoming necessary, and to permit the galvanizing of fine wire gauze without filling the meshes.

### A New Conductivity Apparatus.

A portable apparatus for the rapid and accurate determination of the conductance of ordinary water and dilute saline liquids has been devised by Messrs. W. Pollard Digby and C. W. V. Biggs, who exhibited it and gave a demonstration at a meeting of the Faraday Society on May 31. It consists of a long-limbed glass U-tube furnished with platinum electrodes, and is so designed as to minimize polarization. The filling funnel and the outlet are attached to the lowest point of the bend, and above the electrodes are overflow pipes to permit of a constant flow of liquid. The tube is mounted on a strong wooden stand furnished with a thermometer. The "conductance meter" used with the tube is the familiar "megger" with a scale graduated in reciprocal megohms.

This apparatus, which can be used in the boiler house or in the open just as well as in the laboratory, provides the engineer and others with simple, rapid and exact means of control in many operations, such as checking the purity of boiler-feed water, the regulation of the softening of hard water, detection and estimation of condenser leakage and of priming, control of chemical oil eliminators, etc.

The addition of one part of sodium chloride in a million parts of distilled water raises the conductivity from 2.5 to 6.6 reciprocal megohms, and the same grade of distilled water has its conductivity raised to 3.5 reciprocal megohms by 0.1 per cent of tap water containing about 18.5 grains per gallon of total solids.

### The Testing of Water by Electrical Methods.

The *Journal* of the Institution of Electrical Engineers has an original communication from Mr. W. Pollard Digby on the examination of water by electrical methods, with the apparatus mentioned in these notes above. The object of the author was to point out the value of simple tests taken *in situ* in safeguarding the owners of steam plants; in deciding when the chemical analyst should be consulted; ascertaining whether condensers are leaking or boilers priming, and controlling oil-eliminating and water-softening plants. These tests were not intended to supersede the analyst, but might serve to indicate when detailed analyses were necessary by detecting changes in the impurities in the water by determinations of its conductivity at any desired temperature and comparison of such determinations with the known value of analyzed samples. With a boiler free from priming a single measurement of the conductivity of the water passing from the condenser to the hotwell will indicate whether the condenser tubes are tight or not.

The author gave details of a considerable number of tests carried out at various power stations under widely varying conditions. The specific conductivity of the water in boilers was found to range from 11.1 to more than 90,000 reciprocal megohms, and consequently in each test for priming it was necessary to plot a curve of the conductivities of varying proportions of the water in the boiler under examination diluted with standard distilled water. A specific conductance of 11 reciprocal megohms indicates an exceptionally pure water containing

only about 10 parts of saline matter per million, while the sample giving 90,000 was very highly charged with sodium carbonate. In most of the tests there was an almost entire absence of priming. An interesting curve showed the relation between hardness and conductance in the Clark process of softening water. As the milk of lime is added to the hard water the conductance steadily falls until just sufficient lime has been added and increases with any excess. The hardness of feed water is ascertained from the conductance with considerable accuracy.

### Market Report.

JULY, 1910.

*Copper* has shown a downward tendency. Starting at £54 10 0 it dropped from the 8th till on the 12th it was under £53, but has since recovered and is slightly firmer at £54.

*Tin* has fluctuated considerably during the month. On the 1st it was £149 18 0, by the 11th it had dropped to £146 15 0, recovering on the 15th to £148 18 0. On the 18th it reached £149 5 0, and remains (26th) at £149 0 0.

*English lead* has been steady at £13, declining slightly to present price, £12 17 6.

*Iron hematite* opened at 64/8, rose on the 5th to 65/6, had dropped by the 7th to 64/4, and touched 63/11 on the 14th. Thence recovered to 64/3.

*Scotch pig* has been rather flat at 54/10, falling slowly after the 11th to present price of 54/7½.

*Cleveland warrants* have been between 48/10 and 48/8, the fall being steady from the 11th. Present price, 48/7½.

|  | £ | s. | d. |
|---|---|---|---|
| Alum, lump, loose, per ton | 5 | 12 | 6 |
| Antimony, black sulphide powder | 24 | 0 | 0 |
| Borax, British refined crystal | 16 | 0 | 0 |
| Sulphate of ammonia, f.o.b. Liverpool, per ton | 11 | 15 | 0 |
| Sal-ammoniac, first, delivered U. K., per ton | 42 | 0 | 0 |
| Copper sulphate, per ton | 17 | 10 | 0 |
| Camphor, 1-oz. tablets | | 1 | 7 |
| Caustic soda, ash, 48 per cent, ordinary, per ton | 5 | 10 | 0 |
| Bleaching powder, 35 per cent, per ton | 4 | 5 | 0 |
| Shellac, standard, T. N. orange spots, per cwt | 3 | 15 | 0 |
| Sulphur, recovered, per ton | 5 | 0 | 0 |
| Carbolic acid, liquid, 97 to 99 per cent, per gal | | | 11½ |
| Hydrochloric acid, per cwt | | 5 | 0 |
| Creosote, ordinary good liquid, per gal | | | 2¼ |
| Naphtha solvent, 90 per cent at 160° C., per gal | | 1 | 1 |
| Platinum, per ounce, nominal | 6 | 10 | 0 |
| Copper ore, 10 to 25 per cent, unit 8/9 to | | 9 | 9 |
| Tin ore, 70 per cent, per ton | 5 | 14 | 0 |
| Mica, small slab, in original cases, per lb 6d to | | 1 | 0 |
| Litharge, flake, per ton | 15 | 10 | 0 |
| Red lead, genuine, per ton | 16 | 0 | 0 |

*India rubber* remained steady for the first half of the month at 10/0½, rising slightly to 10/1½ by the 13th. It then declined and stands at present at 9/6.

Of the chemicals it will be noticed that sulphate of ammonia is quoted slightly higher, shellac a little cheaper and platinum higher than last month.

*London, July, 1910.*

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In making screen analyses care must be taken to insure the complete separation of the slime which, in the dry state, adheres to the larger particles of ore. A combination wet and dry method of making these analyses gives excellent results. A convenient weight of the sample is dried and then washed in the finest screen it is proposed to use. The residue on the screen is then dried and the operation repeated on the next coarser screen, proceeding thus until the grading is completed. This method gives great accuracy and allows no loss by dusting. Time is saved in spite of the repeated dryings and washings, as the end of each screening operation is quickly noted. The method is well worth trying.

# Synopsis of Metallurgical and Chemical Literature

**Elastic Breakdown of Certain Steels.**—In a recent Iron and Steel Institute paper of C. A. M. SMITH the usual methods of tension tests are first discussed. The stress at elastic breakdown is generally obtained by dividing the total pull on the specimen in the testing machine by its area. This, however, does not give in general the maximum stress, but the mean stress. In order to obtain the maximum stress at elastic breakdown it is necessary to obtain the measurements of longitudinal strains in three places. Then if the material is elastic and obeys Hooke's law, it is possible to calculate the maximum stress upon the material during a tension or compression test. A great deal depends upon the method of gripping specimens. Detailed experiments along these lines showed that the strain distribution differs widely at different parts of the specimen and in different tests. When using V-grips it seems that the load should be taken up a few tons and then back to zero before carrying out the test proper. Although this unsatisfactory action of V-grips is generally recognized, it is frequently asserted that all the difficulties are overcome by the use of spherical seats. But by a detailed analysis of the stress distribution when using the ball seat, the author shows that friction plays an important part. The bearing stress on the spherical seat during a tension test becomes very great, and any lubricant used becomes squeezed out. The author then comments on the lack of uniformity of material under test; in case of a special steel he proves that it was not uniform. He then compares at some length the effect of time and increase of load, immediately after elastic breakdown, on the different steels tested. Finally, he remarks that until recently all of our knowledge of static testing was obtained from a consideration of one test; he then discusses the more interesting problem: what is the effect of a second stress? He made experiments with certain kinds of steel, a direct stress being obtained as a result of a tension or compression load, and a shear stress by means of a torsion load. The results are plotted in form of curves. They seem to suggest that the materials which most closely obey the shear stress law (or Guest's law) are those which show a decided elastic breakdown at a certain test. An appendix is added on the strength of pipes and cylinders.

**Crystallography of the Iron-Carbon System.**—A recent Iron and Steel Institute paper by ADOLPHE KROLL, JR., gives an extended discussion of this subject. The principal results are summed up as follows: "The polyhedral structure of beta and gamma ferrite has been shown for the first time by heat-tinting, the allotropic theory of Osmond being thereby confirmed. The iron-carbon stability diagram is considered from the legitimate standpoint of crystallographically uniform but mechanically dissectable phases, on the basis of the observation that a mixed crystal continues to grow in either of its components separately. It may be taken as established that, in the solid state, the processes are at first of a purely crystallographic character and independent of equilibria of diffusion (which have hitherto been regarded as the main criteria). The dissolving, or precipitating, phase is the seat of the crystalline force in all cases. The progressive growth of the martensitic austenite bodies in alpha and beta iron, accompanied by their modification into and deposition as gamma iron, was demonstrated by heat tinting. Similarly the continued growth of the same polyhedra of martensite into the cementite—accompanied by powerful transformation phenomena in the latter—was determined; and from this the existence of a solution-carbide, crystallizing according to the regular system, was deduced. Quenching experiments enabled pseudomorphs of this transformed and deposited cementite to be identified, these occurring as elongated cubes, in contrast to the hexagonal crystalline form of the cementite.

"Grounds were discovered for the assumption that the regular solution-carbide strives after saturation with gamma iron, thus forming the constituent troostite (the x constituent). Consequently, the existence of a system of partial isomorphism was recognized, to which belong the solution-carbide and the unstable troostite-saturation line, this system being established, in an intermediately free state, during tempering. It was recognized that the hexagonal-cementite system proceeds, in a partially cryptodimorphous manner, from the isomorphous system, and enables the crystallographically stable equilibrium to find expression. Consequently, a crystallographical double diagram had to be established as stability diagram, from the iron-carbon alloys, the said diagram allowing all the constituents of the isomorphous system to appear intermediately as unstable tempering—or deposition products previous to the complete establishment of the crystallographically stable equilibrium of the cryptodimorphous system.

The independence of the chemical processes with relation to the crystallographic stability diagram was recognized for certain cases, and, therefore, the contingency of primary or secondary establishment of a special purely chemical equilibrium. The existence, in iron-carbon alloys, of a purely chemical system differing in its nature and form from the two aforesaid purely crystallographical stability diagrams, was recognized. This system adheres formally to the lines of the former (Charpy-Heyn) diagram of graphite solubility, while following the carbide decomposition reaction of Wüst and Goerens. This special, chemically stable equilibrium is established in accordance with special, and always chemically homogeneous phases, the result being achieved in such a manner that the partially isomorphous system, is, for the most part, chemically unstable while the partially cryptodimorphous system is chemically metastable, and, therefore, the crystallographical double system may be entirely mutilated, chemically. (From advance sheets.)

**Homogeneity of Metals; Rails.**—A recent Iron and Steel Institute paper of GREGORY TAGAYEFF, of St. Petersburg, emphasizes the importance of studying the microstructure of metals for practical engineering purposes. There exist data showing that all values obtained from mechanical tests of different specimens of iron and steel are in harmony and that the curves of the different properties of the specimens, arranged in the series of any one value—for instance, hardness, tenacity, or carbon content—are parallel to each other. This circumstance often renders it possible to ascertain the character of the metal by one test; for instance, by simple tensile stressing. Such a method of procedure, however, only yields a reliable result under the condition that the treatment and the homogeneity of all the specimens shall be the same. Of these two conditions non-homogeneity is in practice the more dangerous, owing probably to the circumstance that in works the possibility of glaring irregularity of treatment is eliminated. The idea of homogeneity is introduced by the theory of elasticity in the considerations of isotronic bodies. But an identification of metals with bodies that are isotropic ignores that complication of structure which is revealed by metallography. The author discusses at some length the influence of non-homogeneity on fracture due to static and dynamic stresses. The influence of non-homogeneity is undoubtedly greater under impact stresses than under static stresses. It is especially important to notice this in connection with repeated light blows. In this case, intrusions of sulphide of manganese, under the influence of constant vibration, gradually develop into small cracks and promote fracture; whereas in statical fracture the presence of sulphide of manganese does not manifest itself in any way. The author's observations on rails gave him the opportunity of noticing this important action of sulphide permeations, consisting chiefly of

manganese sulphide, especially in those cases where it fills up cracks or is observed as irregular markings on the outside. The author finally refers to an exhaustive investigation of rails taken from Russian railways by the Rail Commission and to a supplementary report by himself, the general conclusions of which are as follows:

Data derived from the study of the chemical composition, in connection with the wear of rails, do not afford an explanation of the difference in their service. Observation of the service of rails and of other articles (shafts, axles, propeller screws, etc.) indicates that local defects in the metal have a predominant influence on their endurance. Flaws and defects observed in rails are particular evidences of non-homogeneity of their internal structure. In order to explain this property it is necessary to call in the aid of metallography which studies the structure of metal.

Structure of steel is determined: (a) by the particular arrangement of the different constituents of the alloy (phases) resulting from its physico-chemical equilibrium as represented graphically by melting curves; (b) by the external features of these structural elements (form, size and distribution) resulting from the so-called structural equilibrium, which depends upon the conditions of initial temperature, rate of cooling, cooling temperature, and external mechanical influences, the sum of which constitutes the mechanical and thermal treatment. A comparison of the results of fractures, with data from microscopical investigation, can be of great use. In particular, such a comparison confirms the existence of a constant definite correlation between the fracture and the microstructure of steel. The mechanical properties of steel are the resultant of the whole of the properties of the structural elements which the steel contains. The mechanical properties of a metal and its quality as measured thereby, are functions of the structure. For this reason the structure affords an indication of the strength and endurance of a manufactured steel article.

**Casehardening.**—A paper presented by Prof. Leon Guillet of Paris before the International Metallurgical Congress in Dusseldorf deals with "cementing considered from the practical and theoretical standpoint." Superficial carburizing is effected with the object of obtaining pieces of machinery with a very hard outer surface and a tough inner portion or core. The main factors which come into play are the steel to be treated, the cementing medium, the temperature and duration of the process, and finally, the thermic treatment of the pieces to be so dealt with. The steel suitable for cementing should contain, unless it be a special steel, not more than 0.120 per cent C, not more than 0.3 per cent Mn and not more than 0.3 per cent Si, and should have in its annealed state a breaking strain of not more than 38 kilograms per sq. mm. (24.13 tons per sq. in.) with a 30 per cent elongation; and after hardening without a subsequent tempering down a breaking strain of 65 kilograms per sq. mm. (41.27 tons per sq. in.). The author gives in his paper the grounds for these conditions. As to the cementing medium he says that this has to be chemically determined and consists mainly of a mixture of charcoal and barium-carbonate. According to the latest experiments of Charpy, this mixture acts solely owing to the formation of carbon monoxide. Recent investigations have afforded a clear proof of the non-cementing property of carbon. The author lays special stress upon the two properties of a cementing medium, i. e., this should not have a too violent action since there would occur a too heavy formation of cementite needle crystals, and it should not be used up too easily. With respect to the question of duration and temperature, the author has collected in tabular form figures showing the influence of these factors. He then deals with the practical side of the question, in regard to the temperature at which cementing commences, and adds that varying views are entertained on the point. He then enters into the question of thermic treatment in detail, for it is in his opinion a fundamental one. The final result is largely dependent upon this treatment. He adds the two following rules which are now followed in modern installations:

1. Cementing at 850 deg. Cent. (1562 deg. Fahr.), quenching once at 750 deg. Cent. (1382 deg. Fahr.)

2. Cementing at 1000 deg. Cent. (1832 deg. Fahr), quenching twice, the first time at 1000 deg. Cent. and the second time at 750 deg. Cent.

After stating the above and giving prominence to the influence of the cementing temperature upon the brittleness of the core previous to the thermic treatment, he adds three important points, as follows:

1. The double quenching carries with it in any case an important advantage, since it causes the cementite which had taken a needle crystallization to disappear.

2. The double quenching leads to the formation in the case of a much more uniform texture, proceeding from a uniform martensite which has tempered down extensively.

3. The brittleness of the core after cementing is the same as when the metal has been subjected to a single tempering action.

Among the tests made with cemented pieces, the determination of hardness by the ball rebounding test is specially referred to. Annealing during five minutes at a temperature of 200 deg. Cent. (392 deg. Fahr.) after cementing appears very advisable for all pieces subject to blows. The author concludes by giving further applications of cementing. He reminds the readers that iron can absorb aluminum, that copper and brass absorb tin, by heating these metals just below their smelting point. He adds data upon the negative results he has obtained in his attempts to get very soft steel to absorb nickel. There is, however, still much to be done along these lines. (From advance sheets.)

A paper on "cementing in a vacuum" was presented at the same Congress by F. Weyl of Aachen. The author carried out a large number of experiments in order to ascertain whether elementary carbon had a cementing action in a vacuum. He took carefully purified natural graphite, also purified kish, separated from pig iron, sugar carbon and diamond. For the experiments he used a furnace in which a vacuum down to a few thousandths of a millimeter could be obtained. The small quantities of gas which developed in the furnace during the tests were immediately removed by the constant action of the air pump. The tests were carried out with the purest electro-ingot-iron obtainable, which, owing to complete freedom from slag, afforded the certainty that no further reactions intervened during heating. In two of the tests the arrangement was such that the smallest amount of gas given out by the cementing medium had to flow past the iron, so that it was possible to ascertain whether the attenuated gases had a carburizing effect or not. The experiments have afforded the proof that under the conditions followed elementary carbon does carburize. It was further ascertained that carburizing only takes place when the cementing agent is in close contact with the iron at a sufficiently high temperature. The experiments with powdered diamond are specially instructive in this connection. In those in which the iron specimens were laid upon the powdered diamond almost no cementing was found to take place at a temperature of 1000 deg. Cent. (1832 deg. Fahr.). This is explained by the fact that the iron specimens were supported solely by a few diamond points, contact with the cementing medium being thus a very imperfect one. When the powdered diamond was strewn upon the iron a heating during 30 hours to a temperature of 975 deg. Cent. (1787 deg. Fahr.) sufficed to produce distinct carburizing. In the latter case the surface of the diamond particles was in contact with the iron, contact between the cementing medium and the iron thus being much more complete. (From advance sheets.)

## Gold and Silver.

**Cyanide Practice at the Dolores Mines in Mexico** is described in the *Bulletin* of the Colorado School of Mines (Vol. 5,

No. 3) by Mr. W. H. PAUL. The principal details of the practice are as follows: Twenty-five stamps crush the ore through 8-mesh battery screen, the product flowing to a 20-mesh King revolving screen. The King screen oversize is reground in Bryan mills fitted with 70-mesh screen. The King screen undersize and the Bryan mill product are united and prepared for table treatment by cone classifiers and hydraulic sizers. The table concentrate is dried and sacked and the tailing passes to Baylis classifiers where separation of sand and slime is effected. The slime passes to the cyanide plant and the sand is ground in tube mills. The latter product is then treated on tables and passes through the classifying system again.

The cyanide plant comprises seven tanks, each 22 ft. in diameter and 15 ft. deep, equipped with mechanical agitators and centrifugal pumps. Two tanks are used for filling, two for agitating and two for settling and decanting; the seventh tank is used for storage for the Butters filter. Two tanks are filled at the same time, requiring about 24 hours, and holding about 150 tons. After filling, the pulp is allowed to settle for about four hours and the mill solution is decanted. A cyanide solution is now added to the pulp, the strength being 0.04 to 0.05 per cent KCN, and the mixture agitated for 24 hours, after which it is discharged to another tank and allowed to settle, the solution being decanted as far as possible. Finally, the pulp is transferred to the storage tank for the Butters filter. The latter has 60 frames 10 ft. x 5 ft. The filter cake is formed in the usual manner and subjected to a wash with weak cyanide solution for an hour, after which a clear water wash is applied. The filtered solution containing the gold and silver is clarified and precipitated in zinc boxes.

The treatment of the zinc box precipitate at this plant is interesting, inasmuch as acid treatment is dispensed with. In the clean-up of the zinc boxes the precipitate flows into a tank equipped with a mechanical agitator; from this tank the precipitate is pumped into a Johnson press. Strong cyanide solution is run into the tank during agitation and also through the press, the overflow from the latter running into a row of zinc boxes so that nothing can be lost. In this way a high-grade bullion is obtained without resorting to acid treatment. The shipped bullion averages 960 fine in gold and silver. The short zinc is treated in an amalgamation pan into which strong solution flows, the outflow passing back to the zinc boxes. The average extraction on Dolores ore for several years past has been a little over 90 per cent of the gold and silver, the former showing higher extraction percentage than the latter. Experiments have been made on cyaniding the concentrate, and extractions of 96 to 98 per cent have been obtained by grinding in pans for 72 hours with very strong cyanide solution.

**Crushing Machines for Cyanide Plants.**—The recent growth of a sentiment among cyanide metallurgists against the use of gravity stamps for crushing preliminary to cyaniding dates from the perfection of the ribbed tube mill liner and of the tall, air-agitation tank. Mr. MARK R. LAMB reviews the steps in this change of opinion, and outlines several combinations of machines that can be used in crushing ore for cyanidation, in the July, 1910, *Bulletin* of the American Institute of Mining Engineers.

The beginning of the surrender of the supremacy of the gravity stamp was in the adoption of tube mills for fine grinding and the use of coarse battery screen. Rolls are usually used where a comparatively small tonnage is to be prepared for coarse concentration, but where no concentration is to be provided for, the combination of rolls and tube mills, without the complication of trommels and elevators, is gaining favor. The next step was the use of the Chilean mill between the stamps and tube mill, which again narrowed the field of the stamp. This combination offers advantages when fine concentration is necessary, but even concentration is not favored in all quarters, and in one instance the use of the concentration table is merely to separate the coarse product which requires further tube milling.

The next step was the abandonment of amalgamation of every product except the concentrate by the Goldfield Consolidated Company in treating a high-grade, free-milling gold ore. This places the stamps at that mill in the class of coarse crushers, and Mr. Lamb believes that the work could be done more economically by rolls if the plant were redesigned.

In considering the steam stamp, Mr. Lamb states that manufacturers are considering a steam stamp that will be intermediate between the Tremain stamp, having a capacity of 20 to 30 tons, and the stamp of Lake Superior district, which crushes 500 to 800 tons.

The success of the pebble mill in cyaniding offers encouragement to adopt another machine from the cement industry, viz.: the ball tube mill. The disadvantages of the ordinary ball mill, with its expensive liners and screens, are entirely avoided in the ball tube mill. Data are quoted from M. W. Von Bernewitz, showing that 120 tons crushed in a No. 5 Gates crusher are handled in three No. 5 ball mills, crushing to 27 mesh. This dry grinding costs 42 cents per ton, and the wear is 3.5 oz. of steel per ton of ore ground. The power required for each ball mill is 16 hp to 20 hp.

Thus there are three machines that can replace gravity stamps where neither concentration nor amalgamation are to be practised. A simple plant would consist of breaker, ball tube mill, classifier and pebble tube mill. Rolls could be substituted for the ball tube mill, and if power is cheap the plant could consist of breaker, steam stamp, classifier and pebble tube mill.

In conclusion, the author finds that: Large tonnages of hard ore are crushed advantageously to 3/16 in., or coarser, by steam stamps; small tonnages of hard rock are crushed advantageously with rolls, which are cheaper than gravity stamps if they are not expected to crush too fine, and are not complicated with screens and elevators, as they would not be for feeding tube mills. Large ball tube mills are available for crushing 3-in. ore to a size suitable for pebble tube mill feed in one operation with no screening. Finally, small steam stamps will probably be at the disposal of metallurgists in a short time, and while we in America have been wondering at the tendency of South African metallurgists to use heavier stamps than we could be persuaded to use, perhaps, after all, we have been fortunately slow.

### Lead.

**The heat of formation of slags** in lead smelting has been investigated by Messrs. H. O. HOFMAN and C. Y. WEN, who have published their results in the July, 1910, *Bulletin* of the American Institute of Mining Engineers. The investigation is interesting inasmuch as heretofore assumptions have had to be made for the heat of formation of the slag in casting a thermal balance of the heat generated and absorbed in a blast furnace treating non-ferrous ores.

The materials used in the experiments were silica, prepared from pure quartz crystals; ferrous oxide, prepared from pure iron and pure ferric oxide; and calcium carbonate, being the precipitated salt sold as chemically pure. The usual method of determining the heat of formation of slag is to mix the slag-forming elements with sufficient finely divided charcoal to raise the temperature of the charge well above the formation temperature of the slag when the charcoal is burned in oxygen in a calorific bomb. The difference between the predetermined calorific power of the charcoal and that of the charge gives the quantity of heat generated or absorbed in the formation of the slag. This method was not used in the present investigation, however, owing to the possibility of reducing some of the ferrous oxide by the charcoal. A satisfactory method was found in fusing the charge in a platinum boat by electricity, the boat to be contained in a bomb and the latter submerged in a calorimeter. The difference between the quantity of heat generated by the electric energy alone and the quantity generated when fusing the charge gives the heat of formation of the mixture.

In every experiment the determination was preceded by duplicate blank tests. The conditions of each experiment were

uniform as to quantity of water (1200 gal.) and time of passing the current (1 min.).

*Ferrous Singulo-Silicate* (FeO, 70.8; SiO$_2$, 29.2 per cent.— The accepted values obtained were 111, 103 and 115 g-cal. evolved in the formation of 1 gal. of ferrous singulo-silicate; average, 109 g-cal.

*Ferro-Calcic Singulo-Silicate* (FeO, 57.58; CaO, 12.00; SiO$_2$, 30.42 per cent.—Calcium carbonate was used instead of calcium oxide, and the heat necessary to split CaCO$_3$ into CaO and CO$_2$ (96 g-cal.) was considered in the results. The average heat evolved in the formation of this slag was 140 g-cal.

*Ferro-Calcic Singulo-Silicate* (FeO, 40.3; CaO, 28.0; SiO$_2$, 31.7 per cent.)—The heat of formation of this slag was found to average 193 g-cal.

The amount of heat evolved is seen to increase with the greater percentage of lime. Experiments were conducted with varying percentages of lime between 0 and 12 per cent CaO, and between 12 and 28 per cent CaO, but many failures were encountered and the gaps were not filled.

**Fine grinding tests** to determine the relative value of the grinding pan and tube mill in regrinding jig tailing for further concentration are reported in the *Transactions* of the Australasian Institute of Mining Engineers, Vol. XIII (1909), by Messrs. W. E. WAINWRIGHT and W. J. McBRIDE. The ore at the Broken Hill South mine assays about 15 per cent lead, 12 per cent zinc and 5 oz. silver. It is a hard ore containing quartz, rhodonite, garnet and feldspar in the gangue. The galena is very finely disseminated throughout the gangue, rendering fine grinding imperative for its liberation.

The system of concentration in use involves jigging, and it is with the jig tailing that the tests are concerned. At the time a grinding pan was introduced Krupp ball mills were used, but the power and maintenance charges were very high. Preliminary work with the pan showed such good results that the Krupp mills were taken out, and grinding pans installed throughout the mill. Later a Krupp tube mill was installed and run in parallel with the pans so that comparative tests could be made. The tube mill was first run with a lining of special toughened steel plates, but these soon wore through and were replaced with 1¼ in. hard cast-iron plates which gave excellent satisfaction.

In the test runs one section of the mill was used comprising rolls, trommels, jig, grinding pans or tube mill, Wilfleye tables and Luhrig vanners. The jig concentrate removed 47.9 per cent of the lead in the crude ore, leaving 52.1 per cent of the lead to be dealt with. Detailed tables are given which show that the pan-ground product was slightly better suited for table concentration than the tube mill product, but the difference was very slight and might with equal justice be referred to inherent differences in the quality of the ore and conditions of treatment. But on investigation of the two machines as crushers, without regard to subsequent concentration, the units of efficiency were found to be in the ratio of 2:1 in favor of the tube mill. Plain liners for the tube mill give very poor crushing efficiency, but the use of bars and that of hard rhodonite lumps instead of small flint pebbles increases capacity.

**Concentration.**—The instances in which a large mining company has opportunity to plan ore dressing works based on a wide past experience with its ore are so few that the published data on such work are very valuable. In the *Mining Magazine* (London) for May, June and July, 1910, GELASIO CAETANI presents some considerations of the theory and practice of concentrating lead-silver ore at the new mill of the Bunker Hill & Sullivan Mining & Concentrating Company. Experiments were conducted over a period of three years to ascertain the best method of treatment for the new mill.

The chief aim was to design a mill of great mechanical simplicity and high economical efficiency. The mill is divided into three departments mechanically independent, viz.: the ore house for the preparation of mill ore; the section for coarse concentration, and that for table concentration. The ore progresses

from one department to the other, undergoing at each step a complete treatment, so that none of the products is ever returned through the channels or over the machines through which it has already passed. This prevents idle circulation of products and makes the mill sensitive to changes in any part. This sensitiveness is taken as an advantage, for no defect in operation can remain long undetected. All of the products of one machine are usually retreated on other machines, the function of which is to rectify the work of the first.

The ore is prepared for milling by crushing and screening in 30-mm trommels. The undersize of the trommels is ready for treatment and is stored in bins of 1900 tons capacity. As the ore is delivered to the mill it passes under a 12-in., 500-volt, ½-amp Browning electromagnet which removes nails, bolts, nuts, etc., which would cause trouble in the mill machinery.

In the mill the ore is screened through 10-mm trommels, which split the ore into two products, 30 mm to 10 mm, and 10 mm to zero. These products are treated in coarse and fine jigs respectively. The jigs split the feed into 14 products, two of which are concentrates ready for shipment, two are tailings, and the other 10 are intermediate products which undergo further reduction.

The feed to the table concentrating department comes from the jigs and consists of jig slime and classifying-jig middling. All pulp passed onto the tables has been through Bunker Hill screens of 22 mesh. Card tables are used. Fine concentration is effected on Frue vanners which treat a thickened pulp of the fine material.

In the coarse concentration department a wider range of sizes is used than is customary in the district. To determine these sizes a 100-ton experimental plant was erected and operated, which showed that with specially constructed Harz jigs it was possible to handle all ore by dividing it into two products, a 30-mm to 10-mm and a 10-mm to zero feed. Both bull and classifying jigs are of the same design except that the latter has a slime separating device in the first compartment, and the bull jigs have one less compartment than the classifying. The gate and dam discharges are all placed at the center of the tailboard and give perfect satisfaction.

The bull jigs separate the following products: 1st, cup concentrate, 52 to 59 per cent lead; 2d, cup concentrate, 40 per cent lead; 3d and 4th, cup middling, 8 per cent lead; tailing, 1 to 1.4 per cent lead, and hitch discharge, 25 per cent lead.

The classifying jigs make the following products: 1st, cup concentrate, 65 to 73 per cent lead; 2d, cup concentrate, 40 per cent lead; 3d and 4th, cup middling, 10 per cent lead; 5th, cup middling, 5 per cent lead; slime discharge from 1st compartment, 14 per cent lead; 1st hutch discharge, 55 per cent lead; 2d hutch discharge, 30 per cent lead; 3d, 4th and 5th hutch discharges, 7 per cent lead; tailing, 1.4 to 1.8 per cent lead.

An interesting device used in connection with the table work is the pipe classifier which concentrates the first and second hutch discharge of the classifying jig, making a 60 to 77 per cent lead concentrate and sending an overflow of lower lead content to the tables. In the table work of the mill the following fundamental principles have been followed: (1) In grinding, the free galena will concentrate almost exclusively in the fine; therefore, the oversize can be screened out and sent to the fine grinding machines without first undergoing a process of concentration. (2) Not to require from any single machine a thoroughly clean work, but to have each operation of screening, classifying or concentrating repeated by other machines on each single product of the first machine.

The screens and classifiers used in the mill are of local design. In the classifier very little hydraulic water is used, and it will not choke or get out of order, even when not looked after for weeks at a time. Certain theoretical considerations and experimental results given by the author lead him to believe that hydraulic classification is preferable to screening, although a perfect classification can never be obtained in practice. Working with a perfectly classified pulp, a table would act as a perfect sizing machine.

## Roasting.

**Recent Progress in Blast Roasting** is detailed rather fully in the June *Bulletin* of the American Institute of Mining Engineers by Prof. H. O. HOFMAN. Both up-draft and down-draft apparatus is considered and the various installations of each described, with details as to actual practice.

Of the up-draft apparatus the Huntington-Heberlein is the best known and most used. At Trail, B. C., this process is used on galena concentrates, the charge being made up to work well in the reverberatory, the blast roast and the blast furnace. It is compounded to contain, Pb, 40 to 44; Fe, 10 to 13; SiO$_2$, 8 to 11; CaO, 7 to 10; zinc, less than 10 per cent. An interesting development of blast roasting at this plant is the roasting of lead blast furnace matte, containing Pb up to 25 per cent, and Cu from 8 to 10 per cent.

At the different works of the American Smelting & Refining Co., where the H-H process is used, variations in practice have to be introduced to meet the conditions. As a rule a considerable amount of experimenting has to be undertaken before the process is worked satisfactorily. The process is of great aid to smelting, however, as is shown by the results obtained at the Murray plant of this company, where a blast furnace formerly treating 160 tons in 24 hours, now treats 200 tons with more ore on the charge than formerly. The blast roaster charge is made up of roasted and raw ore in proportions to keep the lead between 18 and 20, the zinc under 10 and the sulphur between 16 and 20 per cent.

The Savelsberg process is in use at the works of the St. Joseph Lead Co., Flat River, Mo. Eighteen pots, in two rows, are used for the roasting and agglomeration of non-argentiferous galena concentrate. The mixture roasted has the following composition; SiO$_2$, 13.12; FeO, 5.90; CaO, 6.60; MgO, 3.30; Pb, 47.40; Zn, 2.10; S, 11.20; H$_2$O, 6 per cent. In the finished product the Pb is 44.2 and the S, 2.30 per cent.

At the Midvale plant of the U. S. Smelting, Refining & Mining Co., blast roasting is carried out in 20 so-called roasting boxes. Each box has a hearth 6 ft. square and 4 ft. deep. When the charge is sintered it is rammed out by an electrically driven ram similar to that used in discharging coke ovens. The charge consists of 33 parts concentrates, 5 to 10 of flue dust and 62 to 57 of fine ore. A priming mixture is used on which the charge is dumped. One of the boxes is kept in commission on the priming mixture.

On copper and copper-nickel ores the blast roast has not been very successful. This has been tried at the Garfield plant of the A. S. & R. Co., and at the Detroit Copper Co., Morenci, Ariz. Better success was had at the Copper Cliff works of the Canadian Copper Co., but the process is not now in use owing to the lack of mechanical appliances.

Three different types of the down-draft apparatus are described in this article, viz., the drum, the straight line and the horizontal table. These embody the principle patented by Messrs. Dwight and Lloyd. The time of treatment in these continuous machines is about 1 minute for each per cent. of sulphur. The drum machine is in operation at Maurer, N. J., and at Baltimore, Md. The feed and suction box are at the top of the drum, and the discharge is effected by an upturned grizzly which scrapes the sinter from the hearth. The straight line machine is in operation at Salida, Col., on a charge carrying about 35 per cent silica and 17.7 per cent sulphur. This charge is made up of lead ore, sulphide concentrate, flue dust and silicious and oxide ore. The sinter carries about 4 per cent sulphur. The machine treats about 50 tons in 24 hours, at a cost of $.75 per ton. In Illinois the cost of similar treatment is $.50 per ton. The horizontal table is in use at Garfield, Utah. The sulphur on the charge is about 30 per cent and the sinter carries about 6 per cent. The annular grate has an area of 126 sq. ft., of which about 50 per cent is effective. The feed hopper and igniter are stationary and the sinter is removed by a scraper and deflecting apron.

## Chemical Engineering.

**Automatic Acid Egg.**—Vol. II of the *Transactions* of the Amer. Inst. Chem. Eng., just published, contains a paper by Mr. RICHARD K. MEADE on an automatic acid egg. The ordinary cast-iron acid egg has proved a most satisfactory method of elevating acids, but its great objection is the constant attention which it requires. On the other hand, it does not get out of order and may always be relied upon to do the work. The author has devised a simple attachment which may be placed upon the ordinary cast-iron egg, and which is designed to operate the valves, thus doing away with an attendant and so making the egg automatic in its action. It is shown in the accompanying illustration. The acid enters the egg by means of the pipe $p$ and leaves by means of the pipe $b$. Air is conducted in by means of the pipe $m$. To the pipe $b$ is bolted an
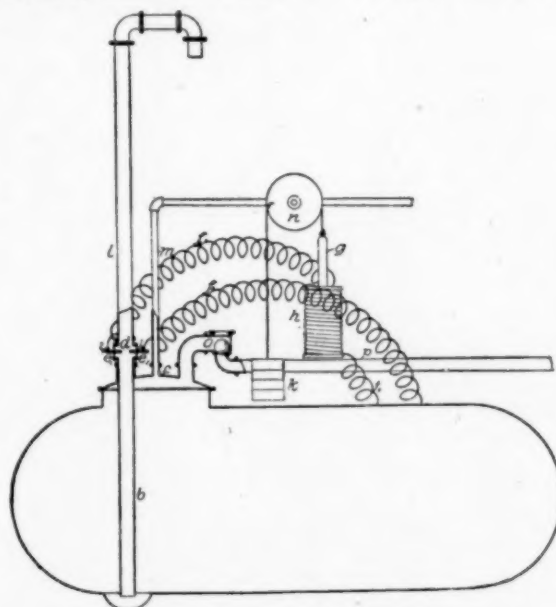


AUTOMATIC ACID EGG.

ordinary cast-iron cross $d$ and to the side openings of this are fastened two porcelain plates $e_1$ and $e_2$. Into these pipes are cemented two ordinary electric light carbons and connected respectively by wires $f_1$ and $f_2$ with the electromagnet $h$, this circuit containing a source of current.

The working of the egg is as follows: The acid flows into it through the pipe $p$ and ball valve $o$ until the egg is full and it rises to a point above the carbon pencils. As soon as it does this, electrical connection is established and the electromagnet $h$ pulls down a core $g$ of soft iron. This latter opens a valve $n$ and allows the air to enter the egg. The check valve $o$ closes, of course, as soon as air enters the egg and causes back pressure in the pipe $p$, and the acid is forced up the pipe $b$. As long as any acid is passing through this pipe, the electrical circuit is, of course, closed and the magnet excited and the valve $n$ is held open. As soon as the current stops the connection is broken and the valve is closed by means of the weight $k$. The valve $n$ is made by simply taking off the wheel from an ordinary glove valve and replacing it by a wooden disk with a groove in the edge in which the cord works. The cord is fastened to the disk at one point $r$ only. In place of the magnet, the connection may be made to start a motor-driven air compressor. The electrical current used for operating the egg may be either from the electric lighting current or from batteries, and the magnet may be located at any convenient point where its workings may be observed. A counter may also be attached to the valve, and if the volume of the egg is known the liquid is so measured. The author has used this device, the feature of which is the simple electrical attachment, for the lifting of sulphuric acid in practice.

# Recent Metallurgical and Chemical Patents

### Iron and Steel.

**Electric Steel Refining.**—In view of Mr. WM. R. WALKER's position as the technical head of the United States Steel Corporation, his latest patent on electric steel refining is of particular interest. In this a prominent place is given to the mixer in a Bessemer converter-electric furnace combination process. The pig iron is treated in an acid-lined Bessemer converter or openhearth so as to desiliconize it and in part decarburize it; from 0.04 per cent to 0.3 per cent of carbon are left in the metal to prevent oxidation of the metal and maintain it fluid. The metal is then run into a suitably heated basic-lined mixer. The metal in its passage to the mixer passes through a spout or runner, which is provided with a skimmer, such as used in the casting of blast furnaces, and by this skimmer, the floating slag is removed from the metal. The metal is thus delivered to the mixer in as nearly slagless condition as possible, since otherwise the acid slag derived from the furnace or converter would prove destructive to the basic lining of the mixer. In this mixer a basic slag is maintained for the purpose of aiding the dephosphorizing of the metal or to neutralize the acid slag which may be mixed with the metal. From the mixer charges are withdrawn from time to time and introduced into basic-lined electric furnaces, where the metal is treated with additions of oxide of iron, together with burnt lime or limestone. In the electric furnace the metal is dephosphorized and desulphurized. This process not only permits to improve the product of the Bessemer converter in such manner as to obtain steel of the quality produced from the open-hearth furnace or by the crucible process, but it also permits to employ for the Bessemer converter iron containing more phosphorus than is permissible in so-called Bessemer iron. The use of the mixer between converters and electric furnaces permits to deliver the metal to the latter in a uniform condition, and to deliver it as required. The application for this patent was filed April 21, 1906. (967,590, Aug. 16, 1910.)

**Nickel-Copper Steel Direct from Ore.**—In connection with the article of C. F. Burgess and J. Aston in our last issue on alloys of monel metal and iron and the article of G. H. Clamer in our present issue on the same subject, a patent of G. H. CLAMER, of Philadelphia, is interesting, which proposes to produce nickel-copper-iron alloys directly from the Sudbury sulphide ores. The alloy can be made within the following range of proportions by weight: Nickel, 25 per cent to 50 per cent; copper, 5 per cent to 20 per cent; iron, 30 per cent to 70 per cent. An alloy containing 65 per cent iron, 25 per cent nickel, 10 per cent copper and 0.2 per cent carbon gave the following test results: On a test bar, ½ in. in diameter and 2 in. between shoulders, strain per square inch in pounds, 96,100; limit of elasticity per square inch in pounds, 51,750; elongation per cent of original length, 42 per cent; reduction of area per cent of original section, 53.7. To make the alloy directly from ore containing nickel, copper and iron in the form of sulphides, the ore is first melted with fluxes to form a slag with the gangue and the production at the same time of an iron-copper-nickel matte. This matte may be of varying composition and, if the iron in the matte is higher than desirable, the matte can be bessemerized, so that approximately the desired amount of iron is removed by the resulting oxidation, and the amount of iron desired for the finished alloy remains. This matte is then calcined to remove sulphur and convert the nickel-copper and iron into oxides. These oxides are reduced with carbon, whereby there is produced a homogeneous alloy of the three metals in the same relative proportions in which they existed in the matte before calcining; the carbon should not be present in amounts producing hard metallic nodules. (965,871, Aug. 2, 1910).

**Electric Steel Furnace.**—The electric furnace of HANS NATHUSIUS, of Friedenshütte, near Morgenroth, Germany, is interesting, since it is known that electric steel refining has been carried out with it at Friedenshütte for over a year. The construction for operation with three-phase currents is shown in Fig. 1. The furnace may be said to combine the Héroult and Girod principles. *abc* are three upper electrodes, as in the Héroult furnace. *def* are water-cooled steel electrodes, embedded in the hearth. These three bottom electrodes are connected to the neutral wire *t* of the three-phase system, while each of the three upper electrodes is connected to one of the three phases. If the switches 5, 6, 7, 8 are open current is
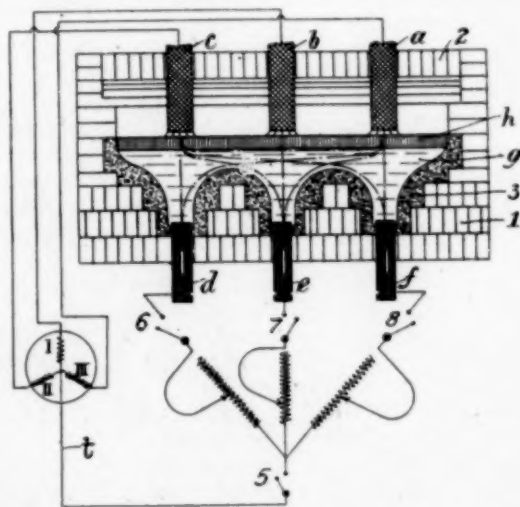


FIG. 1.—STEEL REFINING FURNACE.

supplied to the upper electrodes only and the furnace operates like a Héroult furnace. When 5, 6, 7, 8 are closed the current will also pass from the lower to the upper electrodes as in the Girod furnace. The latter current may be varied by means of the adjustable resistances shown. (958,757, May 24, 1910.)

**Combined Induction and Resistance Furnace.**—J. H. REID, of Newark, N. J., patents an electric furnace in which the resistance heating of the charge by means of a current sent into the charge through electrodes or terminals is supplemented by "induction heating." For this purpose an induction coil is provided which may be suspended more or less into the charge to produce greater or smaller heating effect. It contains a central, annular, current-conducting coil, surrounded by an annulus of soft laminated iron rings, which are in turn surrounded by a cover of refractory material. (956,544, May 3, 1910.)

**Calcium Silicide.**—If calcium silicide is produced from lime, silica and carbon in an electric furnace according to the reaction $CaO + 2 SiO_2 + 5 C = Ca Si_2 + 5 CO$, the difficulty is experienced that the silica and lime have a tendency to unite directly and form silicates of lime. To prevent this, GEORGES STRAUSS, of Paris, France, employs calcium carbide instead of lime and metallic silicon instead of silica, the reactions being as follows:

$$CaC_2 + 2 SiO_2 + 2 C = CaSi_2 + 4 CO,$$
$$2 Si + CaO + C = CaSi_2 + CO.$$
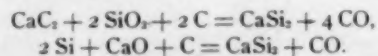
"Experiments made with calcium silicide have shown that this metallic silicide is capable of replacing with advantage the aluminium usually employed in steel works for the purpose of preventing the formation of blow holes in steel ingots. The advantages ensuing from such application are, in addition to the economy secured by the very low price of calcium silicide, very great rapidity of reaction and the suppression of the undesirable

'shortness' which aluminium communicates to ingots of steel." (964,459, July 12, 1910. Assigned to Soc. An. Co. Generale d'Electrochemie de Bozel.)

**Blast Furnace Charging.**—In charging blast furnaces, the ore, coke, etc., is drawn up by a skip and discharged usually from one side into a hopper. By reason of this side discharge the material is unevenly distributed on the bell of the main hopper and consequently unevenly distributed in the furnace. Mr. WALTER KENNEDY, of Pittsburgh, interposes an intermediate receptacle between the receiving and main hopper, provided with a movable closure in combination with means for rotating the receptacle any desired distance so that the material in the receptacle may be discharged at any desired point upon the bell of the main hopper. (955,885, April 26, 1910.)

**Briquetting Iron Ore.**—W. J. SHAW, of Toronto, Ont., Canada, mixes 100 lb. of magnetic iron oxide sand or other pulverized iron ore with 10 lb. or 20 lb. powdered charcoal, sufficient for combination with the oxygen of the ore, 6 lb. to 10 lb. of silica sand, and 10 to 20 lb. carbonate of sodium. These are mixed dry and then saturated with an adhesive vegetable paste, like a solution of potato starch, in hot water. Such a composition when mixed together in about an hour forms a solid briquette which incloses the particles of the pulverized ore within a pure carbon protecting it from the oxygen of the blast and from phosphorous fumes when fuel containing these impurities is used. (963,400, July 5, 1910; assigned to the International Tool Steel Company.)

## Gold and Silver.

**The Adair-Usher process** of lixiviating sand with cyanide solution was developed in South Africa and is known to most metallurgists. Briefly, it consists of circulating the solution by introducing it into a central chamber in the bottom of the vat, whence it travels through radiating pipes and issues through apertures in the pipes and thus rises through the mass of sand. Mr. C. E. D. USHER, of Johannesburg, Transvaal, has recently received letters patent on the distributing pipe which is used in the process. It comprises an outer pipe which is connected with the chamber at the center of the vat and extends through the wall of the vat. This pipe is perforated and is placed preferably with the perforations on the under side. Within this outer pipe is another closely fitting pipe which may be turned by means of a handle at the end outside of the vat. Both ends of the inner pipe are plugged, but it has a large aperture in its side near the end which extends into the central chamber, and also has other apertures along its length to correspond with the apertures in the outer pipe. When the vat is filled with the pulp to be treated, the solution is pumped through the central chamber into the pipes radiating from it, the openings in the latter being adjusted by turning the inner pipe within the outer. When the lixiviating process is completed the openings may be closed and thus the pulp is prevented from clogging the pipes and preventing the even distribution of solution to every part of the vat. (965,767, July 26, 1910.)

**Slime Filter.**—A novel idea in centrifugal slime filters has been patented by H. V. HOLMAN, of Colorado Springs, Col. It consists of a rotor, which is made of heavy wire screen covered with canvas or other filtering medium, into which the pulp to be filtered is conducted. The rapid revolution of the rotor produces filtration by centrifugal action. The accumulated sand on the filter bed is continuously loosened and removed by a plurality of disks which are supported within the rotor, and which may be moved to or from the filtering surface in order to remove more or less of the accumulation. The disks are not fixed in their position and therefore do not offer great resistance to the rotation of the screen and are not subject to excessive wear. The inventor claims superiority over fixed screw types of excavators in centrifugal filters in that the excavation is more complete, and, therefore, the capacity of the filter greater; the disks are not likely to become stuck if the

machine is fed too heavily or run too fast; varying thicknesses of filter bed can be formed owing to the adjustment of the possition of the disks. (966,918, Aug. 9, 1910.)

## Roasting.

**Multiple-Hearth Roaster.**—Improvements in the type of roaster known as the McDougall, are proposed by W. M. BARKER, of McGill, Nevada, who has assigned his interest to the Allis-Chalmers Co., of Milwaukee, Wis. It is proposed to cool the rabble arms by means of air introduced at the bottom of the hollow vertical shaft, which carries the rabble arms on each hearth of the furnace. At the ends of the rabble arms are holes for the exit of the heated air into the furnace. An improvement in the rabbles consists in the use of a rabble holder suspended from the rabble arms by flanges. Each rabble holder has two wedge-shaped slots passing through it, the slots intersecting near their centers. The rabbles have dovetail shaped ends, which fit into either of these slots depending on the direction of rotation of the rabble arms on which they are placed. The pitch or inclination of the rabbles in the lower hearths is greater than that of the rabble in the upper hearth; and the rabbles of the upper hearth are wider than the rabbles of the lower. This arrangement will tend to more readily break up any wet or sticky ore fed onto the upper hearth. The advantage of having the slotted holders is that any holder can be used on any hearth and can be made either right or left handed by changing the rabble from one slot to the other. (951,081, June 7, 1910.)

## Tin.

**Detinning Tin Scrap.**—For detinning purposes C. J. REED proposes to make use of the fact that metallic tin is rendered weak, friable and easily pulverized by heating to about the melting point of tin. Tin scrap is mixed with an equal volume of finely divided quartz, sand, etc., and the mixture charged into a rumbler, wherein it is subjected to heat and agitation until the tin is entirely removed from the iron. The product is then thrown upon a screen which separates the pieces of detinned iron from the powdered tin and sand. The tin and sand powder mixture is placed into a closed vessel into which dry chlorine gas is passed. Gaseous stannic chloride passes out and is recovered in a condenser. (958,177, May 17, 1910.)

**Detinning.**—E. C. HIGGINS, of Bayonne, N. J., patents mechanical details of an apparatus in which tin scrap is detinned by placing it in a heating basket which is rapidly revolved. The tin melts and is thrown out of the basket through wire mesh by centrifugal force. (965,580, July 26, 1910.)

## Aluminium.

**Aluminium from Sulphate.**—A new aluminium process is the object of a patent of H. F. D. SCHWAHN, of Belleville, Ill. He first produces by an older process aluminium sulphate, which he mixes with pitch, the mixture being heated in a closed container to 900° C. This results in the formation of $Al_2(SO_4)_3.C_{12}$, which is an "electric resistance material or electrolyte" of coke-like appearance. This is treated in an electric furnace with a flux of fluorides of the alkalies, or alkaline earth metals, in a reducing atmosphere of producer gas, with a "gaseous flux," as fluorine in form of hydrofluoric acid vapors. The result is stated to be aluminium free from carbon or aluminium carbide. (964,566, July 19, 1910.)

## Alloys.

**Magnesium Alloys.**—G. PISTOR and P. RAKOWICS of the Chemische Fabrik Griesheim Elektron, at Frankfort-on-the-Main, Germany, proposes the use of high-percentage magnesium alloys, containing from 80 per cent to 99.5 per cent magnesium and from 0.5 per cent to 20 per cent of other metals, for any mechanical purposes, especially automobiles, airships, instruments and for military and sporting purposes. These alloys can be readily machined, soldered, welded, forged and cast; they have a high tenacity and elasticity and low specific gravity. An alloy of 92 per cent magnesium and 8 per cent aluminium has a specific gravity of only 1.75 and "strength and

extensibility equal to the best gun metal." Alloys of magnesium and zinc or of magnesium and copper are "greatly superior in their physical properties to the usual aluminium or its alloys." The well-known alloy "magnalium," which is an alloy of aluminium and magnesium, containing at most 25 per cent magnesium, is stated to be very different from these high-percentage alloys. (965,485, July 26, 1910.)

### Electric Furnaces.

**Calcium Carbide and Cyanamide.**—A process has been devised by E. H. MEYER and J. M. A. STILLESEN, of Niagara Falls, Ontario, Canada, for the object of producing calcium carbide from the raw materials in a single operation and utilizing the gaseous products from the reduction of coal and limestone to preheat the charge and to obtain (from the air used thereby) nitrogen for the manufacture of calcium cyanamide. The arrangement of the plant is shown in Fig. 2. The finely crushed raw materials, limestone and coal, are fed through 4 into the upper half of the stack 1. This upper half forms a retort for conversion of the limestone into lime and of the coal into carbon. The reduced lime and carbon is then dropped down into the receiver 3, from which it is fed to the electric furnaces 5 by means of the pumps 6. These furnaces are arranged around the bottom of the receiver; only one of the furnaces 5 is shown in the illustration. It is inclined to the vertical, as shown, for the purpose of getting better efficiency and to enable the charge to be supplied at the bottom of the furnace at the hottest part. 8 is a movable electrode (controlled by the motor 10) and 9 a fixed bowl-shaped electrode. The reaction in the electric furnace is, as is well known, $CaO + 3C = CaC_2 + CO$. The carbon monoxide evolved in this reaction is utilized as follows:

From the furnace 5 a gas vent pipe 12 connects with rings 13, from which the gas is supplied to the conical burner 14 in the retort 2, after being mixed with air, and burned therein to reduce the coal and limestone. A sufficient supply of air is admitted with the gas to burn all the carbon monoxide and hydrogen in the retort 2 to carbon dioxide and water, so that
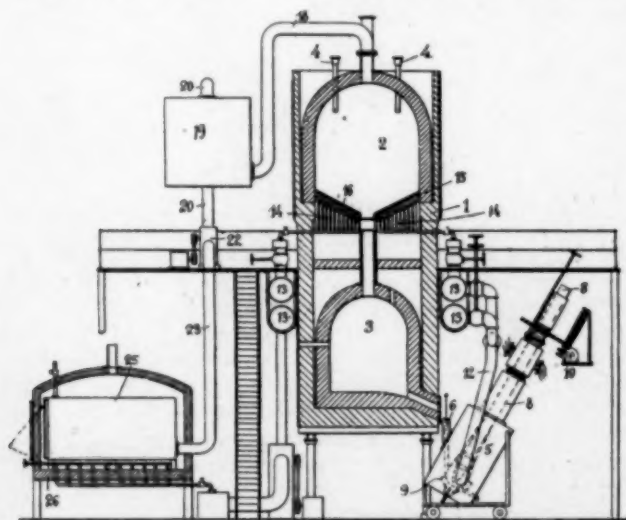


FIG. 2.—CARBIDE AND CYANAMIDE PLANT.

the gases passing out at the top through pipe 18 will consist principally of carbon dioxide, water and nitrogen. A valve controls the admission of air. Pipe 18 leads through a cooler (not shown), thence to a tank 19 containing calcium hydrate, which absorbs the water and carbon dioxide, but not the nitrogen which was introduced as a part of the air. From tank 19 the nitrogen passes by pipe 20 through a fan 22 to a dryer, not shown, thence through a pipe 23 to the cyanamide furnace 25. This latter furnace consists of an air-tight drum on a foundation 26, and is heated by carbon monoxide gas from the carbide furnace, if desired, ignited by acetylene or other means.

In carrying out the process the coal and limestone charged into retort 2 is admitted to reservoir 3 and thence fed, while still hot, into the furnace 5, and thence the melted carbide, when formed, is tapped out from the bottom of the furnace 5 and is ready for use after being cooled and crushed, in making calcium cyanamide, or for other purposes. Since the charge is hot when introduced into the carbide furnace and is fed at the bottom at the hottest zone, the electrical energy required is relatively small. (965,393, July 26, 1910.)

**Carborundum.**—A continuous process for the manufacture of carborundum has been devised by FRANK J. TONE, of the Carborundum Company, of Niagara Falls, N. Y. A ver-
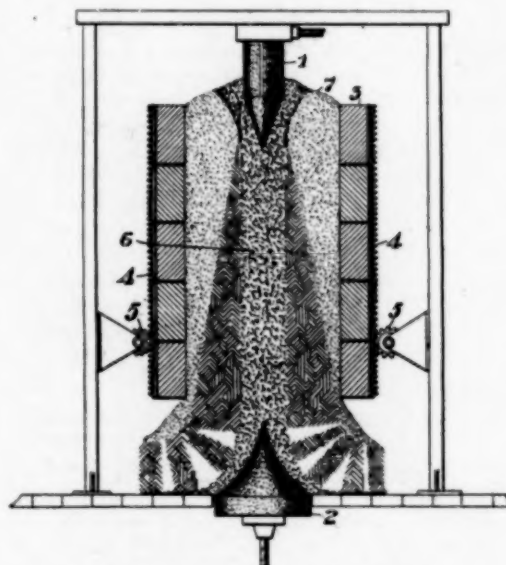


FIG. 3.—CARBORUNDUM FURNACE.

tical furnace for this purpose is shown in Fig. 3. The side walls are formed of transversely divided refractory sections 3 secured to rack sections 4, which engage with pinions 5. A continuous downward movement of the walls with the charge inside is then produced. In the center of the charge is the resistor consisting of granular core material which is supplied at and around the upper electrode. This granular resistor core is surrounded by the charge mixture of carbon and silicious material 7, which is also supplied at the top. The lower electrode is pointed or conical so that the core material and finished product are deflected outward so as to be easily removed. A horizontal furnace embodying the same fundamental idea is also described. (965,142, July 19, 1910.)

**Metallic Electrode.**—In the production of metals or alloys which are intended to be free from carbon, FRED. M. BECKET, of the Electro-Metallurgical Company, of Niagara Falls, employs metallic instead of carbon electrodes. A suitable form is a hollow block of cast iron with connections for the circulation of cooling water. Wrought iron may be employed instead of cast iron. Where particularly high temperatures are used, electrodes of a metal or alloy of high melting point, like ferrotitanium, may be used; in this case the cooling medium may sometimes be dispensed with. (967,159, Aug. 16, 1910.)

### Electrolytic Processes.

**Bicarbonate of Soda.**—A modification of the Solvay process is patented by R. H. F. FINLAY, of Belfast, Ireland. He follows the earlier steps of the well-known ammonia soda process up to the point at which the mother liquor has to be dealt with. That is to say, he treats the brine with ammonia and carbonic anhydride so as to obtain a precipitate of bicarbonate of soda, ammonium chloride being left in solution as well as some undecomposed sodium chloride and some ammonia and carbonic anhydride, chiefly in the form of bicarbonate of ammonia. The precipitated bicarbonate of soda being removed and treated in the usual manner the mother

liquor is passed directly or after treatment with carbonic anhydride into the cathode chamber of an electrolytic cell. The ammonium chloride in the mother liquor is here electrolyzed and ammonia is set free at the cathode and combines with carbonic anhydride, if present, chlorine being set free at the anode. In some cases he adopts the well-known expedient of introducing carbonic acid to the cathode chambers by a pipe. After electrolysis, the liquid which now contains some common salt and the ammonium chloride which was not decomposed by electrolysis may be used instead of brine in the first reaction of the process, in which, meeting with the ammonia liberated by electrolysis and carbonic anhydride, bicarbonate of soda is
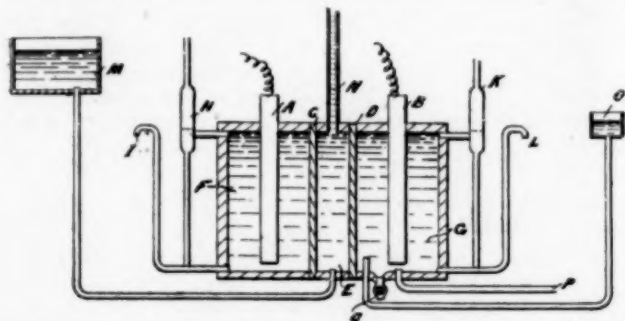


FIG. 4.—ELECTROLYTIC CELL FOR BICARBONATE OF SODA.

again precipitated and the mother liquor again treated as described. If salt be added to the mother liquor before, and carbonic anhydride be injected during electrolysis, bicarbonate of soda may be formed in the cathode chamber of the cell. In this case the chamber should be made larger than would otherwise be necessary and be furnished with suitable means for removing the precipitate. The cell is shown in Fig. 4. A is the anode, B the cathode and the anode chamber F is separated from the cathode chamber G by the intermediate chamber E. The gases from the anode and cathode chambers are collected in H and K, respectively. M is a vessel containing brine and N a column of liquid at the same level as in M, producing pressure on the electrolyte chamber. On operation F and E are filled with brine. G is filled from O with liquor containing ammonium chloride. Chlorine is evolved at A in small bubbles which pass over with liquid into H, where the separation of the chlorine gas from the liquid takes place. The solution deprived of portion of its salt by electrolysis flows off at I. In like manner ammonia and hydrogen are evolved at B. When carbonic anhydride is passed through P into G it combines with the ammonia. If the ammonium chloride liquor in this case is saturated with common salt before entering O bicarbonate of soda is precipitated in G and may be removed. (961,945, June 21, 1910.)

### Electroplating.

**Zinc Plating.**—In a patent of Dr. E. F. KERN, of Columbia University, the following electrolyte is recommended for zinc plating: 100 parts by weight of water, 12 or more of zinc fluosilicate, 10 or more of aluminium fluosilicate, 10 or more of grape sugar, and 5 or more of ammonium fluoride. A zinc anode is employed. In certain cases, in order to restrain the separation of silica, it is advisable to add ammonium fluoride from time to time, this material being added to the bath at the outset in the proportion of one part of ammonium fluoride to one or more parts of zinc. (967,200, Aug. 16, 1910.)

**Electroplating Mirrors.**—A patent of EMILE HOORICKX, of Brussels, Belgium, relates to the deposition on silvered mirrors of a protecting layer of copper by electrolysis. Details of a mechanism for immersing the mirror in the electrolytic bath are described. By a single manipulation the frame carrying the mirrors and that carrying the anode are immersed in the bath in such a manner that the mirrors travel obliquely into the bath and are completely immersed in it before the frame

carrying the anode has entered the bath. The oblique passage of the mirrors into the bath avoids the disturbance of the liquid which occurs when the mirrors enter the liquid normally to the surface. On the other hand, the fact that the mirrors are completely immersed before the frame carrying the anode enters the bath has the important result that there can be no localization of the current on a small portion of the silvering of the mirror which would result in its burning. (966,097, Aug. 2, 1910.)

### Batteries.

**Manufacture of Storage Batteries.**—According to universal present practice, the spongy lead of the negative plate of the lead accumulator is produced or formed in situ either by repeated oxidations and reductions of the support itself (Plante process) or by reduction of a compound of lead mechanically applied to the grid (Faure-Brush process). PEDRO G. SALOM, of Philadelphia, proposes a radical change of this practice by producing the active material in bulk outside and applying it mechanically to the grid, whereby the plate is finished. A mass of spongy lead is produced by electrolytic deposition or electrolytic reduction, thoroughly washed with cold water, passed under stirring or rubbing through a sieve of 40 mesh, and is then exposed to the atmosphere and stirred to permit evaporation of the water. While the evaporation proceeds, a thin superficial coating of suboxide of lead is formed throughout the interstices of the spongy mass. For the success of the process it is of importance that this be stopped at the proper moment. The feel of the damp mass is a suitable indication which when squeezed between the fingers should have the "temper" of molding sand; it then contains still moisture, about 5 per cent in bulk of the total mass. In this state the superficially suboxidized spongy lead is applied to the grid and compressed within the compartments by means of heavy pressure (1500 lb. per square inch). The finished plate presents smooth faces, flush with the thickness of the frame and main bars. The chief advantages claimed for this process over present practice are that the new plate, while remarkably homogeneous, carries a greater quantity of spongy lead and that the cost of producing the spongy lead electrolytically in bulk and applying it mechanically to the grid is less than the cost of an equivalent amount of litharge, as employed in actual practice. (960,115, May 31, 1910.)

## A New Dry Ore Concentrator.

Dry concentrating machines have attracted the attention of inventors for several reasons, but chiefly because material carrying gold or valuable mineral is found in arid places where water is not obtainable in sufficient quantity to operate wet concentrators, or because some material possesses properties which prevent successful treatment by ordinary wet concentration.

The McKesson Concentrator Company, of Colorado Springs, Col., has developed a dry concentrator which is intended to treat ore and placer gravel. As shown in the accompanying illustration, the machine is of steel construction throughout, with the exception of the belt, which is of some suitable cloth fabric. The machine is 5 ft. long, 4 ft. wide and 5 ft. high, and requires a floor space of 6 ft. x 6 ft. Supported on the steel frame is a fan and a triangular box into which an air current is forced. The triangular air chamber is closed on all sides with the exception of the top, over which the porous apron or belt is caused to move around three driving pulleys fitted with sprocket wheels and connected with chains. The two top pulleys are fixed in position, while the bottom or tension pulley is adjustable to keep the traveling belt in proper tension. The pitch of the table from feed to discharge end is adjusted by hand by means of a pulley and wire cable at the discharge end of the machine, the feed or head end being fixed, while the discharge or tailing end can be lowered to any desired point.

The area of the concentrating surface is 3 ft. by 4 ft., and consists of that portion of the belt which is traveling horizontally, or nearly so, across the two upper driving pulleys. The belt travels at the rate of 1½ r.p.m. to 2½ r.p.m., and at right angles to the flow of the material being treated, carrying the concentrates with it to the side of the machine, and allowing the tailing to pass down and over the edges of the belt.

Ore is fed through an adjustable automatic feeding device at the upper edge of the belt, and forms a thin bed on it. The fan, revolving at the rate of 2100 r.p.m., delivers a current of air into the air chamber beneath the concentrating surface. The air is forced through the pores of the belt in innumerable jets, and produces a stratification of the particles forming the bed of ore, forcing the lightest to the top and leaving the heaviest at the bottom. The current of air delivered by the fan is properly regulated by means of a gate between the fan and air chamber.

Supported immediately above the belt is a series of fixed iron bars, conveniently called launders, placed 6 in. apart and extending from feed to discharge end of the machine. These launders serve to direct the flow of the lighter particles down the table to the tailing discharge. Adjustable cross-riffles, so-called, made of wires placed 2 in. apart and extending in the direction of the travel of the belt, are supported above the belt between the launders.

When the machine is in operation it will be seen that the belt will be forced firmly against these launders and cross-riffles, which give the appearance of a grid-iron to the bed of ore on the belt. By lowering these cross-riffles below the launders at any point, the heaviest material on the belt settles into the depression formed and is allowed to pass under the launders with the belt, and is delivered at the side of the machine. The cross-riffles are arranged in three sections, each end section having six riffles and the middle section seven.

To recapitulate, the launders direct the flow of the upper lighter strata of the bed of ore toward the tailing discharge; the cross-riffles may be depressed at points below the launders, pressing the belt away from the launders and allowing the settled concentrate to pass with the belt to the concentrate delivery. By depressing these cross-riffles at the proper points, different minerals, such as galena and pyrite, can be withdrawn
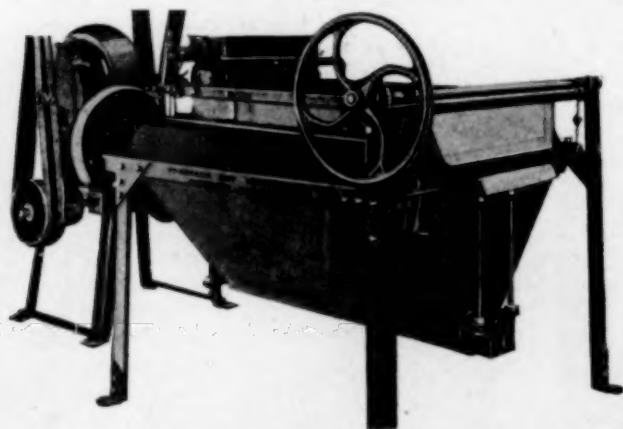


DRY CONCENTRATOR.

as separate concentrates; the minerals of highest specific gravity will be drawn off first, those of lower specific gravities next, and the lightest material will discharge as tailing. Finally, just as the concentrate is about to be delivered, provision is made to clean it with air coming up at the edge of the air chamber.

Various materials are used for the belt. For dry slime, a satin belt has been found best; for fine ore, a sateen belt, and for coarse ore, a twill or light canvas. These materials are inexpensive and durable, one sateen belt sufficing for the treatment of about 200 tons of ore. One man can make the change of belts in 20 minutes. Provision is made for cleaning the

belt after it has delivered its concentrates by means of a device which periodically strikes the belt a sharp blow.

The machine works best with closely sized ore and has a capacity of 7 to 50 tons of ore, or 200 to 500 cu. yd. of placer dirt in 24 hours. There is absolutely no vibration of the machine during operation, which is quite a factor in determining its durability.

The weight of the concentrator is 850 lb., the heaviest piece weighing 110 lb.

Following are the results of recent tests on a Leadville zinc-lead-iron sulphide ore, which is one of the latest to be treated successfully.

The products were a lead concentrate, an iron middling carrying some lead, and a zinc tailing carrying all of the silicious gangue.

The test was made principally to determine the possibility of obtaining a clean lead concentrate from an ore known to carry a small percentage of that metal, with zinc and iron in larger quantities.

### TEST NO. 1.

Capacity, 7½ tons per 24 hours — 29 + 39-mesh material.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 6.7 | 23.2 |
| Lead concentrate | 69.3 | 2.6 |
| Iron middling | 8.2 | ... |
| Zinc tailing | Trace | ... |

### TEST NO. 2.

Capacity, 7 tons per 24 hours, of — 39 + 49-mesh material.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 7.8 | 24.3 |
| Lead concentrate | 63.0 | 3.4 |
| Iron middling | 10.6 | ... |
| Zinc tailing | Trace | ... |

### TEST NO. 3.

Capacity, 7½ tons per 24 hours, of — 49 + 60-mesh material.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 5.4 | 24.8 |
| Lead concentrate | 54.7 | 4.5 |
| Iron middling | 7.6 | ... |
| Zinc tailing | 0.9 | ... |

### TEST NO. 4.

Capacity, 36 tons per 24 hours, of — 60 + 72-mesh material.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 6.6 | 24.5 |
| Lead concentrate | 70.3 | 2.4 |
| Iron middling | 7.6 | ... |
| Zinc tailing | Trace | ... |

### TEST NO. 5.

Capacity, 15 tons per 24 hours, of — 72 + 97-mesh material.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 7.0 | 25.0 |
| Lead concentrate | 68.0 | 2.0 |
| Iron middling | 10.6 | ... |
| Zinc tailing | Trace | ... |

### TEST NO. 6.

Capacity, 11 tons per hour, of — 97 + 109-mesh material.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 7.3 | 23.9 |
| Lead concentrate | 59.5 | 7.5 |
| Iron middling | 6.7 | ... |
| Zinc tailing | 0.4 | ... |

### AVERAGE.

| | Lead per cent. | Zinc per cent. |
| --- | --- | --- |
| Original ore | 6.8 | 24.3 |
| Lead concentrate | 64.1 | 3.6 |
| Iron middlings | 8.6 | ... |
| Zinc tailing | 0.4 | .... |
| Ratio of concentration | ... | 9.5:1 |
| Percentage of lead recovery | ... | 94.8 |

## Water Pressure Reducing Valve.

The following note describes a new automatic valve for reducing a high water pressure to low pressure and maintaining the reduced pressure constant; it is fitted with a quick-opening electrically operated attachment which is used whenever the full pressure is desired.

The valve as shown in the sectional view is in a closed position. The spring $B$ is adjusted by the bronze sleeve $A$ (in which it is encased) to the desired pressure. This spring acts on diaphragm $C$, moving auxiliary valve $D$, unseating same. The pressure or inlet side of the valve is at $E$. The low-pressure or outlet side is at $F$. The water on the high-pressure side fills the inlet chamber, exerting a pressure on upper valve $I$ and lower valve $J$ and large piston $K$. The pressure also passes through the port $G$ into chamber $L$, and as the spring $B$ is holding the auxiliary valve $D$ open, the water passes on through towards port $N$ to the pressure at which the valve or spring $B$ is set. The pressure, still increasing, moves the
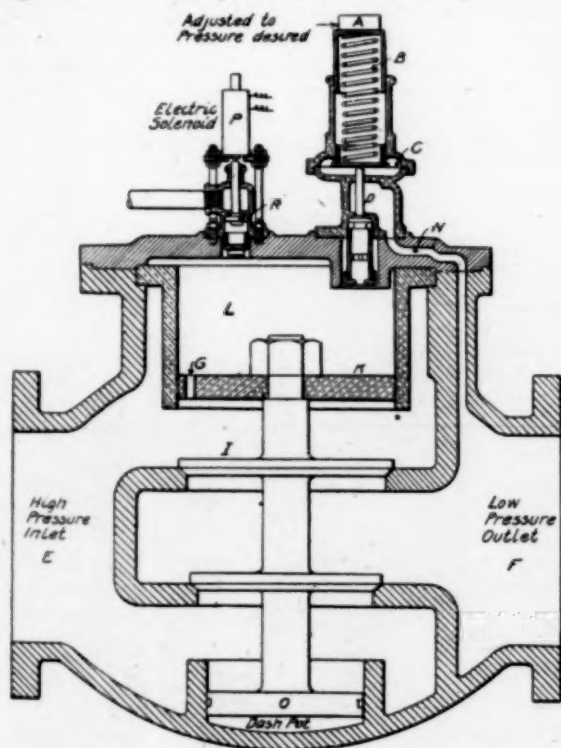


WATER-PRESSURE REDUCING VALVE.

diaphragm $C$ upwards, compressing spring $B$ and allowing the auxiliary valve $D$ to close. The main valves $I$ and $J$ are forced to their seats by the initial pressure, shutting off water from the system. The pistons $O$ and $K$ prevent chattering and act as a perfect cushion in the opening and closing of the valve.

The electric solenoid which controls the auxiliary valve is wired up to the switchboard at the pumping station, and in case the full pressure is desired (for instance, in case of fire) the switch is closed, which causes the electric solenoid to open the small auxiliary valve and exhaust the water pressure from above the large piston $K$, which allows the main valve to instantly open to the full area. When the full pressure of water is no longer required, the switch is opened. This allows the small auxiliary valve to instantly close. The main valve then automatically returns to the regulating position. The brass ball covering the port below valve $D$ prevents any water returning through the port $N$ from the low-pressure side.

This valve is one of the latest designs of automatic control valves gotten out by the Golden-Anderson Specialty Company, of Pittsburgh. They are prepared to build it in sizes from 3 in. to 20 in. and for any required pressure up to about 300 lb.

per square inch. It will operate satisfactorily with as big a reduction in water pressure as 3 to 1 ratio and is now in service in gravity water systems for mines and other industrial works and for municipal supply installations.

## Condensers.

BY DR. OSKAR NAGEL.

The application of vacuum has lately been found advantageous in a good many industries for carrying out various operations, such as evaporating, drying, distilling, etc. Three different kinds of apparatus enter into this application, namely: (1) the dryer or distiller; (2) the vacuum pump; (3) the condenser.

Dryers and distillers have already been described at length in the columns of this paper. The vacuum pump is too well known, as regards construction and operation, to require further description. We will, therefore, in this article confine ourselves to a discussion of condensers.

Condensers may be divided into two groups: (1) surface condensers and (2) jet condensers. In both types condensation is effected by means of water. While, however, in the surface condenser the products of condensation do not come in contact with the water (both being separated from each other by the wall of a pipe), an intimate mixture of water and the products of condensation is effected and obtained in the jet condenser.

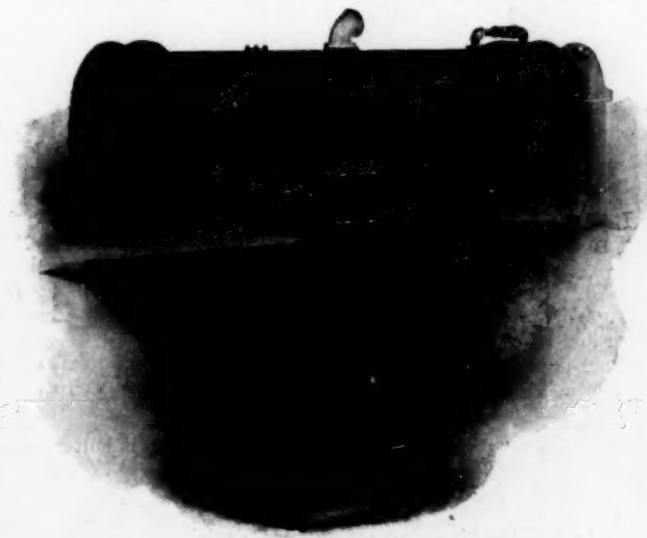This also explains the field of application of each type.



FIG. 1.—SURFACE CONDENSER.

Where the condenser products are to be kept separate from the water, the surface type should be used. Where a mixture of condensed product and water is admissible or not objectionable and where the products of condensation are simply to be removed and vacuum is the only desideratum, the jet condenser is the proper and only apparatus to use.

Fig. 1 shows an Alberger surface condenser. Its construction is readily understood from the illustration.

Fig. 2 shows a Koerting jet condenser, which operates upon the well-known jet principle. A jet of pressure water $C$ passing from a smaller into a wider nozzle of a peculiar construction creates a vacuum, draws in the products to be condensed from $E$, condenses them, and discharges them together with the water. We see immediately that this type, wherever applicable, is vastly superior to the surface condenser wherever fresh water is to be had, since the jet combines the action of the vacuum pump with the operation of the condenser. Pressure water is the only requirement for starting and operating the jet condenser.

The jet condenser, Fig. 2, goes by the name of single-jet eductor condenser, and is satisfactory for medium-sized plants,

while for use in very large plants the multi-jet eductor condenser, Fig. 3, is more efficient and is, therefore, in these instances to be preferred.

With the type shown in Fig. 2 a single condensing jet is used and this passes centrally through a long cylindrical tube provided with a series of rings of holes for the passage of the exhaust steam from the condenser chamber to the jet. The holes are drilled obliquely, directing the steam at suitable angle, so that it impinges on the condensing jet in the direction of flow. The steam, which strikes the condensing jet at high velocity, is condensed, and the particles of water into which it is converted having the kinetic energy due to the steam velocity cut into the jet and contribute to the momentum needed to discharge this together with the entrained air and non-condensible gases against the resistance of the atmosphere.

The Koerting multi-jet eductor condenser, shown in Fig. 3, works on the same principle, but has instead of one central condensing jet a number of converging jets meeting and forming a single jet in the lower part of the condensing tube. This tube is cast in one piece, and consists of a series of concentric nozzles of gradually diminishing bore. The water enters at B and the steam coming from A flows through the annular passages between the nozzles, which guide it so that it impinges at suitable angle on the condensing jets.

The multi-jet condensers are considerably shorter than the single-jet apparatus of equal capacity, but in spite of this the area of contact between the steam or gas and the water is greater. A further advantage is gained by the form of the condensing tube, which in vertical section is an inverted cone. In the upper part of the tube the steam is in contact with the coldest water and there the condensation is keenest, so that a greater weight of steam is condensed per unit of area of contact than in the lower part of the tube where the water is hotter.

FIG. 2.—JET CONDENSER.

## NOTES

**Patent Lawsuit.**—An interesting decision has recently been rendered in a lawsuit involving electrical panelboards The suit against B. Altman & Company, a dry-goods house of New York City, was brought on patent No. 705,850 of July 29, 1902, granted to Hubert Krantz and later assigned to the Krantz Manufacturing Company. The defendants raised a novel point, claiming that the patent was incongruous for the reason that the claim specified an alleged invention different from that which was described in the specification and drawing. Judge Hand, sitting in the United States Circuit Court of the Southern District of New York, accepted the point and held the patent invalid because of the difference between the claim and specification and dismissed the bill with costs. Mr. Warren Wright argued for the complainant and Mr. C. P. Goepel, of Goepel & Goepel, appeared for the defendants.

**Mechanical Gas Producer.**—The Forter Miller Engineering Company, Pittsburgh, are issuing an attractive booklet on gas producers giving a description of the new Forter-Trump mechanical producer. This is an adaptation of the well-known Forter water-sealed producer, the Trump automatic feed and ash extractor having been added. The latter device consists of a slowly revolving wedge-shaped knife which forces out the ashes and causes the fuel bed to regularly drop in pie-shaped

segments. A full description with illustrations appeared in the June issue of this journal. With air fed from both the outside and the center of the bosh a large grate area is obtained and figures on a 10-ft. producer of the Forter-Trump design are: Coal gasified, bituminous nut size, 30 tons per day, or nut and pea, 25 tons; calorific efficiency, gas used hot, 85 per cent; calorific efficiency, gas cooled to 80° F., 80 per cent; carbon in ash, 3.5 per cent; power required to run knife, 1 hp. The data on the new producer is preceded by a brief discussion of the advantages of producer gas as a fuel, and followed by illustrated descriptions of the Forter water-sealed gas producer, bell and hopper-feeding devices, the Waldburger patented feeding device, the Eynon-Evans blower, the Forter water-controlled reversing valve and the Forter water-sealed reversing valve. The water-controlled valve is a device for reversing regenerative furnaces and its unique feature is that the valve is stationary and the reversal of the circulation is accomplished through raising and lowering of bodies of water sealing or opening the passages, as desired, corresponding to the operation of the metal-sealed movable valve. The catalog will be of interest to men connected with the producer end of iron and steel industries and of glass houses and other works where producer gas for fuel is required.

**Motor-Driven Pumps** is the title of circular No. 1512 recently issued by the Westinghouse Electric & Manufacturing
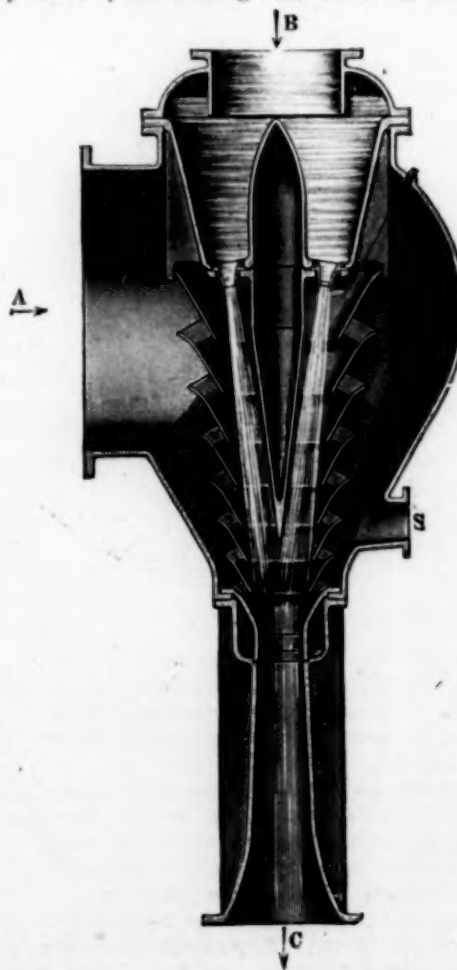


FIG. 3.—MULTI-JET EDUCTOR CONDENSER.

Company, of Pittsburgh. It is pointed out that for nearly all purposes except in certain high-duty pumping installations electric drive can be recommended on account of its economy, convenience of location, cleanliness, and comparative noiselessness, small floor space and ease of control, the last feature adapting itself to either hand, remote electric or automatic

operation. Several photographs of typical motor-driven units with pumps of both reciprocating and centrifugal design are shown. For mine pumping the electric drive has still additional advantages and portable mine pumps mounted on trucks, together with the motor, are in use throughout the country.

**Corrosion-Resisting Paint.**—The Sterling Varnish Company, Pittsburgh, have recently sent out a booklet giving notes on their products: Sterling raw refined linseed oil, Sterling clear iron enamel, and Sterling black iron enamel (carbon base and asphalt base). With this booklet has been included a sample of thin gage sheet iron enameled and lettered. The lettering shows quite readily through the clear iron enamel, which is designed to give to structural steel a preliminary protective coating which can be applied all over without obliterating the necessary markings or preventing the detection of flaws, scale or rust. The black iron enamel is intended for use on exposed steel work, bridges, buildings, roofs, etc., and it has a good record for withstanding severe service. Sterling raw refined linseed oil is the base of the above products, and is also put upon the market separately. The purity of the oil in any paint is of prime importance as ordinary oil and much of the so-called refined oil contains impurities which are dissolved by rain or dampness, leaving the paint coating full of little flaws which permit rapid disintegration. By the "Todd processes" practically all of these soluble impurities are removed and the irregularities which ordinarily give trouble are absent. The "ten commandments," one might say, to which the Sterling Varnish Company subscribes are summed up in the following: "If you keep a coat of paint free from any opening through which outside influences can enter and have its coefficient of expansion properly adjusted, you attain the maximum of durability."

**The Stearns-Roger Manufacturing Company,** Denver, has issued an illustrated catalog describing the Edwards mechanical roasting and chloridizing furnaces, and the Edwards dryers and coolers. A number of installations of both simplex and duplex furnaces, of the tilting and fixed hearth types, are shown. The roasters are widely used in Australia, as well as in this country.

**The Isbell Vanner** is to be installed in the new mills of the Chino and Ray Consolidated Copper Companies. Over 1500 of these machines will be used, being the largest number of one make of vanners ever ordered at one time. The Galigher Machinery Company, of Salt Lake City, received the contract, and will have the machines made by the Allis Chalmers Company.

## PERSONAL

Mr. **H. C. Beeler,** mining engineer of Denver, recently returned from Wyoming, where he is engaged in the development of asbestos properties.

Mr. **A. C. Dart,** who has held the chair of mining engineering in the University of Wyoming, has resigned that position to accept the general managership of the Rambler Copper & Platinum Company, at Holmes, Wyo.

Mr. **Courteney DeKalb** has resigned his position as one of the editors of the *Mining and Scientific Press,* to become general manager of the Pacific Smelting & Mining Company, Sonora, Mexico.

Mr. **Carl F. Dietz,** of the firm of Dietz & Keedy, Boston, sailed for Europe last month, and will attend the joint meeting of the Mechanical Engineers at Birmingham and London.

Mr. **F. W. Draper** is now with the Arizona Smelting Company, Humboldt, Ariz., having recently returned to the United States after fulfilling a two years' engagement in the Urals, Russia.

Mr. **J. E. Edwards,** representing the Edwards furnace, has removed from Colorado Springs to Denver and has an office with the Stearns-Roger Manufacturing Company.

Mr. **Ivan E. Goodner,** formerly with the Bogardus Testing Laboratories, of Seattle, Wash., is now in the new concentrates cyaniding plant of the Alaska Treadwell Gold Mining Company and will be located at Treadwell, Alaska.

Mr. **John A. Hunter,** formerly in the Southwestern States and Mexico, has established a metallurgical laboratory in Los Angeles.

Mr. **D. C. Jackling,** general manager of the Utah Copper Company, recently made a trip of inspection through Nevada and Arizona. He was accompanied by other officials of the Guggenheim Exploration Company and American Smelting & Refining Company.

Mr. **C. Colcock Jones** has returned to Los Angeles from an extended professional trip in Esmerelda County, Nevada.

Mr. **Jules Labarthe,** who has been superintendent of the Canadian Smelting Works, at Trail, B. C., for the past 10 years, has taken charge of the construction and operation of the new smelter of the Mason Valley Mining Company, at Yerington, Nev.

Mr. **J. R. Masson,** of Australia, is the United States representative of the A-Z agitator, and has offices at 2 Ferguson Building, Denver.

Dr. **Jos. W. Richards,** of Lehigh University, has sailed for Europe to attend the International Geological Congress in Stockholm.

Prof. **Robert H. Richards,** of Boston, is spending a part of the summer in Denver.

Mr. **Guy M. Vail,** of Portland, Ore., has recently been in Nevada on professional business.

Mr. **Pope Yeatman** was recently in Leadville, Colo., as an arbiter in differences between the Empire Zinc Company and the Western Mining Company. He was called upon to decide the question of ownership of ore in adjoining properties on the same ore body.

## Digest of Electrochemical U. S. Patents.

Prior to 1903.

*Arranged according to subject matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

ELECTRIC FURNACES (*Continued*).

No. 675,576, June 18, 1901, Alfred H. Cowles, Cleveland, Ohio. The furnace has a crucible, whose walls are permeable to gases, surrounded by double walls to form two chambers, the inner one for permitting gases to be drawn off, the outer one having suitable connections to form a water jacket. An electrode depends into the crucible through a cover of compacted carbon incased in an iron shell, insulating material being placed between the bottom of the cover and the crucible. The electrode is surrounded by a pipe, connected to but insulated from the iron shell of the top, this pipe having a chamber at its top into which is introduced a small quantity of hydrocarbon, neutral or reducing gas or gas-forming liquid to prevent any vapor passing up around the electrode. The electrode terminal passes through a stuffing-box into the chamber, current passing from one terminal to the electrode through the charge to the crucible and surrounding casings or jackets to the other terminal.

No. 676,985, June 25, 1901, Hugo Koller, Nuremberg, Germany. Resistance type especially for calcium carbide. End electrodes project into horizontal chamber. Between and in line with these electrodes are a series of disconnected electrodes supported above the bottom of the furnace. A second series of disconnected electrodes are located on the bottom of the furnace between the ends of the raised electrodes. The lower electrodes may have troughs formed in their tops to receive molten carbide. The charge covers all the electrodes. The furnace is started by inserting a small resistance such as short carbons

between adjacent ends of electrode blocks. The object of the invention is to have as few feed conductors as possible and to increase the limits of voltage between which furnace works advantageously.

No. 677,070, June 25, 1901, Arthur H. Eddy, of Windsor, Connecticut.

Resistance type, especially for fusing enamel upon clay or metal. A longitudinal furnace is shown having transverse resistors, consisting of groups of parallel carbon rods enclosed in larger porcelain tubes, both electrically connected at each end to water-cooled clamps. After being heated to a high degree, the porcelain tubes become fair conductors and carbons may then be removed. The resistors may be arranged to provide for gradually increasing and then decreasing temperatures, as articles are fed through the furnace. The porcelain tubes protect the fused enamel from disintegrated carbon particles and from air jackets which assist in equalizing temperature.

No. 677,439, July 2, 1901, Ramon Chavarria Contardo, of Sevres, France.

Arc type. Prevents electrodes from getting hot outside of the furnace by means of a water-cooled hollow metal sleeve, through which electrode slides, embedded in the refractory wall of the furnace and carefully insulated from metal fittings. This sleeve may be made in two pieces, copper plates being wound spirally around the electrode, and the half-sleeves tightened in place by spring rings. Electrical connection to the electrode is made through bronze segments (which may be water-cooled (surrounding and pressed against the electrodes by concentric rings, each segment being connected to a strand of the cable. Successive carbons are attached, the rear ends having conical holes into which project correspondingly shaped front ends, the mechanical connection being made by a carbon cotter and the electrical connection by varnish containing graphite and sugar or tar. A single sleeve composed of hollow bronze water-cooled segments may serve both for cooling and electrical connection.

## BOOK REVIEWS.

**Die Wärmetechnik des Siemens-Martinofens.** By. Dr.-Ing. F. Mayer, Professor of Metallurgical Engineering at the Institute of Technology in Aachen. 123 pages, 29 diagrams. Halle: Wilhelm Knapp, 1909.

Dr. Mayer investigated most thoroughly a 30-ton basic open-hearth furnace at the Rothe Erde works near Aachen, working on a charge of 72-73 per cent scrap, 15-20 per cent pig iron, ored down by hematite and deoxidized by spiegeleisen and ferro-manganese. The yield was 34-35 tons, time averaging six hours, coal used in producers 250 kg per ton of steel, surface of metal 0.6 sq. m per ton of steel.

Measurements were made for a month of all the details of operation, including particularly analyses of the producer gas and chimney gas, and temperatures at the upper outlet of all four regenerators, at the gas and air inlets, and at the chimney flue, using Le Chatelier thermo-elements. The temperature curves through the regenerators, also the change in composition of the gas as it was being heated, were followed. All the original data are given in extensive tables, so that any one can use them to draw his own conclusions. The principal conclusions drawn by Dr. Mayer on this particular furnace (but probably largely true of all open-hearth furnaces) are interesting and have an important bearing on open-hearth practice.

The air should be heated to 1450° to 1500°, the gas to 1300° to 1350°. Reversing every 20 minutes, the temperatures at the outlet of the air regenerator should not fall over 100° to 120°, of the gas regenerator not over 180° to 200°.

The temperature difference between the hot air and the hottest part of the air regenerator is not over 20°.

The depth to which the heat enters the regenerator bricks varies directly with the time between reversals; the effective weight of regenerator material is therefore dependent on the same.

With producer gas at 600°, the gas regenerator returns only 60 to 70 per cent as much heat to the furnace as the air regenerator.

The producer gas could be cooled in order to remove its moisture and sulphur, and yet be heated to the same temperature if the gas regenerator were made 10 per cent larger.

In regular running, about one-sixth of the gas is burned in the regenerators after leaving the furnace. This is because of the great velocity with which the gases traverse the hearth.

Hydrogen gas is consumed proportionately quite as completely in the furnace as CO gas. Both CO and $H^2$ burn in the regenerators.

This heat developed in the regenerators is practically lost to the furnace.

No heat in the chimney gases below 600° can be utilized.

Chimney gases at 600° give a much better draft than at 300°, which is useful for running the furnace, as it enables it to draw in more air and gas and do faster smelting.

Hydrogen is not advantageous in the producer gas, because it makes it lighter and more inclined to rise and burn along the roof of the furnace, which it thus injures.

Only half the steam blown into the producers was decomposed therein.

In the regenerators, each cubic meter of checker work contained 790 kg of bricks, and had 16 sq. m of surface.

The air chamber had 20 sq. m and the gas chamber 15.5 sq. m of checker surface per kilogram of coal burned per minute. Each square meter of checker surface yielded 7400 calories per hour to the air, and 4400 calories per hour to the gas.

The regenerators lost by radiation and conduction about 17 per cent of the heat intercepted by them (including that developed in them by combustion).

The body or laboratory of the furnace utilized for heating charge and supplying radiation and conduction, 43 per cent of the calorific power of the coal used in the producers.

Many of the above conclusions evidently apply only to the particular furnace investigated by Dr. Mayer, but some are of great value to open-hearth practice in general. We recommend the close study of this book to all interested in the theory or practice of the regenerative gas furnace, and take this opportunity to congratulate the author on his splendid work.

## NEW BOOKS.

**Allen, Alfred H.** Commercial organic analysis. Fourth edition. Vol. 3. Hydrocarbons, asphalt, phenols, aromatic acids, modern explosives. 645 pages, illustrated. Price $5. Philadelphia: P. Blackiston's Sons & Co.

**Benson, Harrison T.** Compendium on mines, mining, minerals, ores, rocks; weights of metals and rocks; effect of heat on various substances; water measure, tanks and piping; atomic weights explained, chemical symbols, etc. Illustrated. Price $2. Denver, Colo.: Hall and Williams.

**Clarke, Fk. Wigglesworth.** Recalculation of the atomic weights. Third edition, revised and enlarged. 552 pages. Smith Inst.

**Coles-Finch, W.** Water, its origin and use. Illustrated. Price $5 net. New York: D. Van Nostrand & Co.

**Crane, Wa. R.** Ore mining methods. Illustrated. Price $3 net. New York: John Wiley & Sons.

**Hegler, Edward C.** In memory of Edward C. Hegler. No paging. Paper gratis. Chicago: Open Court.

**Osborn, S. Stafford.** Prospector's field book and guide in the search for and the easy determination of ores and other useful minerals. Eighth edition. Price, $1.50. Baird.

**Treadwell, F. Pearson.** Analytical chemistry. Translated from the German by W. T. Hall. Vol. 2. Quantitative analysis. Second edition, thoroughly revised and enlarged. Price $4. New York: John Wiley & Sons.